K-Means Clustering of People with COVID-19

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1. Source Code

1.1. Code for Creating Database

❑ **CreatingDB Class**

```
class CreatingDB:
    """
    Class for creating random database
    """
    num_people = 0  # number of people to create
    base_date = None  # the base date of data

    def __init__(self, num_people, base_date):
        self.num_people = num_people
        self.base_date = base_date

    def generate_incurred_date(self):
        """
        function to create random incurred date
        :return:
            incurred_date: string, the day of infection or contact
            elapsed_days: int, the difference between base date and incurred
date
        """
        elapsed_days = random.randint(0, 14)  # the valid day period is 0~14
        # extracting the incurred day using periods and base date
        incurred_date = (self.base_date - timedelta(days=elapsed_days)). \
            strftime("%Y %m %d")
        return incurred_date, elapsed_days

    def generate_address_list(self):
        """
        function to get one address randomly from the adress list
        :return: the randomly generated address list
        """
        with open('./Address_Part.txt', 'r', encoding='utf-8') as add_file:
            # add_file = add_file.encoding
            address_list = add_file.readlines()

            random_address_list = []  # list to store addresses

            # extract addresses as many as the number of recipients
            for _ in range(1, self.num_people + 1):
                random_address_list.append(random.choice(address_list))

        return random_address_list

    def generate_csv_data(self):
        """
        function to create .csv file with randomly generated records
        :return: None
        """
```

```
        num_healthy = round(self.num_people / 3)  # 1/3 is healthy
        num_contacted = round(self.num_people / 3)  # 1/3 is contacted
        # 1/3 is confirmed
        num_confirmed = self.num_people - num_healthy - num_contacted

        id_list = list(range(1, self.num_people + 1))  # ID as many as people
        random.shuffle(id_list)  # shuffle list

        # age records as many as people
        age_list = list(random.randint(1, 100)
                        for _ in range(1, self.num_people + 1))
        # address records as many as people
        address_list = self.generate_address_list()

        severity_list = []  # severity records as many as people
        incurred_date_list = []  # incurred date list including 'None'(healthy)
        status_list = []  # status(Healthy, Contacted, and Confirmed) list

        # Entire people num = healthy + contacted + confirmed
        # Repeat as many healthy people
        for _ in range(num_healthy):
            # severity_list.append(0)
            status_list.append('Healthy')
            incurred_date_list.append('None')

        # Repeat as many contacted people
        for count in range(num_contacted):
            date, days = self.generate_incurred_date()
            status_list.append('Contacted')
            #     severity_list.append(round(self.compute_severity('contacted',
days), 2))
            incurred_date_list.append(date)

        # Repeat as many confirmed people
        for _ in range(num_confirmed):
            date, days = self.generate_incurred_date()
            status_list.append('Confirmed')
            #     severity_list.append(round(self.compute_severity('confirmed',
days), 2))
            incurred_date_list.append(date)

        # converting as pandas DataFrame data type to save .csv
        df = pd.DataFrame({
            "ID": id_list,
            "Age": age_list,
            "Address": address_list,
            "Covid Status": status_list,
            # "Severity": severity_list,
            "Incurred Date": incurred_date_list,
        })
        df = df.sort_values(['ID'], ascending=[True])
        df.reset_index(drop=True, inplace=True)

        # saving as .csv file
```

```
        df.to_csv("corona_data.csv", mode='w', encoding='utf-8-sig')
```

1.2. Code for Clustering

❑ **ClusteringPeople Class**

```
class ClusteringPeople:
    df_corona = None
    added_column_list = []
    cluster_result_dic = {}

    centroids_coord_list = []

    num_healthy = 0
    healthy_id_list = []
    num_contacted = 0
    contacted_id_list = []
    num_confirmed = 0
    confirmed_id_list = []

    def __init__(self, file_path):
        self.load_data(file_path)
        self.compute_severity()
        self.compute_people_number_of_type()

    def load_data(self, file_path):
        """
        method to load .csv file
        :param file_path: string, the path of file
        :return:
        """
        self.df_corona = pd.read_csv(file_path)

    def compute_people_number_of_type(self):
        status_series = self.df_corona["Covid Status"]
        for idx in range(len(status_series)):
            if status_series[idx] == 'Contacted':
                self.num_contacted += 1
                self.contacted_id_list.append(idx+1)
            elif status_series[idx] == 'Confirmed':
                self.num_confirmed += 1
                self.confirmed_id_list.append(idx+1)
            else:
                self.num_healthy += 1
                self.healthy_id_list.append(idx+1)

    def compute_average_severity(self, id_list):
        sum_of_severity = 0
        for id in id_list:
            sum_of_severity += self.df_corona["Severity"][id-1]
        return sum_of_severity / len(id_list)
```

```
    def display_load_data(self):
        print(f"Total number of People: {len(self.df_corona)}")
        print(f"{'ID':<4}"
              f"{'Age':<4}"
              f"{'Covid Status':<13}"
              f"{'Severity':<9}"
              f"{'Address':<10}")
        for i in range(len(self.df_corona)):
            print(f"{self.df_corona['ID'][i]:<4}"
                  f"{self.df_corona['Age'][i]:<4}"
                  f"{self.df_corona['Covid Status'][i]:<13}"
                  f"{round(self.df_corona['Severity'][i], 3):<9}"
                  f"{self.df_corona['Address'][i].split()[0]:<10}"
                  )
        print()  # float 1 line
        print(f"Number of healthy people: {self.num_healthy}")
        print(f"Number of contacted people: {self.num_contacted}")
        print(f"Number of confirmed people: {self.num_confirmed}")
        print(f"Average Severity of contacted people: "
              f"{round(self.compute_average_severity(self.contacted_id_list),
2)}")
        print(f"Average Severity of confirmed people: "
              f"{round(self.compute_average_severity(self.confirmed_id_list),
2)}")
        print()  # float 1 line

    def compute_severity(self):
        """
        method to preprocess the data for distance function
        :return: None
        """
        col_num = len(self.df_corona)  # the number of rows from loaded data
        today = datetime.now().date()  # date of today, YEAR-MONTH-DAY

        # selecting specific column to compute 'severity'
        incur_date_col = self.df_corona['Incurred Date']
        status = self.df_corona['Covid Status']

        severity_list = []  # list for storing severity result

        for i in range(col_num):
            severity = 0  # default is healthy, 0.
            if status[i] == 'Contacted':  # contacted person?
                # formula for contacted person:
                #   x = 1 - ((today's date) - (infected date)) * 0.05)
                elapsed_days = (today - parse(incur_date_col[i]).date()).days
                severity = (1 - (elapsed_days * 0.05)) * 0.5

            elif status[i] == 'Confirmed':  # confirmed person?
                # formula for confirmed person:
                #   x = (1 - ((today's date) - (infected date)) * 0.05)) / 2
                elapsed_days = (today - parse(incur_date_col[i]).date()).days
                severity = 1 - (elapsed_days * 0.05)
```

```
            severity_list.append(severity)  # add the value to the list
        self.df_corona["Severity"] = severity_list
        self.added_column_list.append("Severity")

    def cluster_kmeans(self, col_name_list, num_cluster):
        # load the k-means model
        km = cluster.KMeans(
            n_clusters=num_cluster,  # the number of cluster
            init='k-means++',  # how to initial cluster centers
            max_iter=300,  # maximum number of iterations
            algorithm='auto'  # three choices: auto, full, and elkan.
        )

        # cluster
        if len(col_name_list) == 1:
            target_data = self.df_corona[col_name_list].values.tolist()
            target_data = np.array(target_data)
            cluster_predicted_list = km.fit_predict(
                target_data.reshape(-1, 1))  # changing the shape of data
            silhouette_score_list.append(
                silhouette_score(target_data.reshape(-1, 1),
                                 cluster_predicted_list))

        else:  # at least 2 column
            target_data = self.df_corona[col_name_list]

            min_max_scaler = preprocessing.MinMaxScaler()
            target_data = min_max_scaler.fit_transform(target_data)

            cluster_predicted_list = km.fit_predict(target_data)
            silhouette_score_list.append(
                silhouette_score(target_data,
                                 cluster_predicted_list))

        # storing the coordinates of centroids
        self.centroids_coord_list.append(km.cluster_centers_)

        # storing the prediction result
        self.cluster_result_dic[num_cluster] = cluster_predicted_list

        return cluster_predicted_list

    def draw_elbow_method(self, sse_list):
        """
        method to draw elbow graph using SSE(Sum of Squares Error)
        :param sse_list: list of SSE
        :return: None
        """
        plt.plot(range(2, 10), sse_list, marker='o')
        plt.xlabel("The Number of Cluster")
        plt.ylabel("SSE")
        plt.show()
```

```
    def print_result_of_cluster(self,
                                num_cluster,
                                cluster_idx_list,
                                cluster_predicted_list):

        severity_list = self.df_corona["Severity"].values.tolist()
        age_list = self.df_corona["Age"].values.tolist()

        cluster_predicted_list = cluster_predicted_list.tolist()
        people_num_of_a_cluster_list = []
        avg_age_of_a_cluster_list = []
        avg_severity_of_a_cluster_list = []

        print(f"Number of Clusters: {len(cluster_idx_list)}")

        for cluster_idx in cluster_idx_list:  # 1 cluster
            num_people = cluster_predicted_list.count(cluster_idx)
            id_target_data_tuple_list = []
            sum_of_severities = 0
            sum_of_ages = 0

            for person_idx in range(len(cluster_predicted_list)):
                if cluster_idx == cluster_predicted_list[person_idx]:
                    sum_of_severities += severity_list[person_idx]
                    sum_of_ages += age_list[person_idx]
                    id_target_data_tuple_list.append((
                        person_idx+1,  # [0] of tuple is id
                        age_list[person_idx],  # [1] of tuple is age
                        round(severity_list[person_idx], 2)))  # [2] of tuple is
severity

            people_num_of_a_cluster_list.append(num_people)

            print(f"\tCluster {cluster_idx}:")
            print(f"\t\tNumber of People: {num_people}")
            print(f"\t\t\t{'ID':<4}{'Age':<4}{'Severity Value'}")
            for person_in_cluster in id_target_data_tuple_list:
                print(f"\t\t\t{person_in_cluster[0]:<4}"
                      f"{person_in_cluster[1]:<4}"
                      f"{person_in_cluster[2]}")

            print(f"\t\tAverage of Age: "
                  f"{round(sum_of_ages / len(id_target_data_tuple_list), 2)}")
            print(f"\t\tAverage of severities: "
                  f"{round(sum_of_severities  /  len(id_target_data_tuple_list),
2)}")
            print(f"\t\tThe Coordinates of Centroid:")
            coords = self.centroids_coord_list[num_cluster-2][cluster_idx]
            print(f"\t\t\tX1 (Severity): {round(coords[0], 2)}")
            print(f"\t\t\tX2 (Age): {round(coords[1], 2)}")

            avg_age_of_a_cluster_list.append(
                round(sum_of_ages / len(id_target_data_tuple_list), 2))
            avg_severity_of_a_cluster_list.append(
```

```
                round(sum_of_severities / len(id_target_data_tuple_list), 2))

            print()  # float 1 line
        self.display_summary_table(people_num_of_a_cluster_list,
                                   avg_age_of_a_cluster_list,
                                   avg_severity_of_a_cluster_list)
        print()  # float 1 line

    def data_to_csv(self, num_cluster, cluster_label_list):
        temp_df = self.df_corona.__deepcopy__()
        temp_df[f"Cluster ID: {num_cluster}"] = cluster_label_list

        file_name = f"clustered_corona_data_k={num_cluster}_" \
                    f"{'_'.join(self.added_column_list)}.csv"
        temp_df.to_csv(file_name, encoding='utf-8-sig')

    def display_summary_table(self,
                              people_of_cluster_list,
                              avg_age_of_cluster_list,
                              avg_severity_of_cluster_list):
        len_id = 11
        len_p_num = 11
        len_age = 13
        len_sev = 15
        len_sum = len_id+len_p_num+len_age+len_sev

        # top row
        print(f"\t{'-'*(len_sum+11)}")
        print(f"\t{'Cluster ID':>{len_id}} "
              f"| {'# of People':>{len_p_num}} "
              f"| {'Avg. of Ages':>{len_age}} "
              f"| {'Avg. of Severity':>{len_sev}} ")

        # contents of table
        cluster_id = 0
        for people_num, avg_age, avg_sev in zip(people_of_cluster_list,
                                                avg_age_of_cluster_list,
                                                avg_severity_of_cluster_list):
            print(f"\t{cluster_id:>{len_id}} "
                  f"| {people_num:>{len_p_num}} "
                  f"| {avg_age:>{len_age}} "
                  f"|{avg_sev:>{len_sev}}")
            cluster_id += 1

        print(f"\t{'-'*(len_id+1)}"
              f"|{'-'*(len_p_num+2)}"
              f"|{'-'*(len_age+2)}"
              f"|{'-'*(len_sev+2)}-")

        # bottom row
        print(f"\t{'Total':^{len_id}}                                                    |
{sum(people_of_cluster_list):>{len_p_num}} |")
        print(f"\t{'-'*(len_sum+11)}")
```

```
    def draw_silhouette(self):
        """
        method to draw graph using silhouette scores
        :return: None
        """
        pass

    def draw_graph(self):
        """
        method to draw clustering result
        :return: None
        """
        pass
```

❑ **main**

```
if __name__ == '__main__':
    # CODE FOR CLUSTERING
    file_path = './corona_data.csv'

    cp = ClusteringPeople(file_path)
    cp.display_load_data()

    sse_list = []  # list for storing SSE(Sum of squares errors)
    silhouette_score_list = []  # list for storing silhouette scores

    # cluster with 'Severity' and 'Age' columns
    col_name_list = ['Severity', 'Age']
    k_list = [k for k in range(2, 10)]  # cluster list

    for num_cluster in k_list:
        cluster_id_list = [id for id in range(num_cluster)]
        predicted_list = cp.cluster_kmeans(col_name_list, num_cluster)
        cp.print_result_of_cluster(num_cluster,
                                   cluster_id_list,
                                   predicted_list)
```

2. Result of Clustering with Single Feature

2.1. Clustering using Scikit-Learn Library

2.1.1. Clustering using K-means

❑ **Used Column: Severity**

❑ **Distance Function: Euclidean Distance**

❑ **Console window results**

```
Total number of People: 100
ID  Age Covid Status Severity Address
1   72  Contacted    0.125    충청남도
2   50  Healthy      0.0      경기도
```

3	49	Contacted	0.2	경상북도
4	45	Contacted	0.225	전라남도
5	45	Contacted	0.325	전라남도
6	66	Confirmed	0.55	부산광역시
7	86	Healthy	0.0	전라남도
8	43	Healthy	0.0	서울특별시
9	63	Healthy	0.0	경기도
10	81	Confirmed	0.35	광주광역시
11	2	Contacted	0.175	경상북도
12	69	Healthy	0.0	전라북도
13	66	Healthy	0.0	전라북도
14	37	Contacted	0.425	울산광역시
15	97	Healthy	0.0	경상북도
16	98	Healthy	0.0	경상북도
17	56	Confirmed	0.65	전라북도
18	26	Contacted	0.3	경상남도
19	90	Confirmed	0.9	전라북도
20	21	Confirmed	0.5	전라북도
21	26	Healthy	0.0	경상북도
22	17	Confirmed	0.45	제주특별자치도
23	55	Healthy	0.0	부산광역시
24	74	Healthy	0.0	경상북도
25	91	Contacted	0.275	경상북도
26	33	Healthy	0.0	대전광역시
27	1	Healthy	0.0	강원도
28	91	Confirmed	0.9	전라남도
29	74	Confirmed	0.45	전라남도
30	52	Contacted	0.275	경기도
31	49	Confirmed	0.4	전라남도
32	49	Confirmed	0.3	전라남도
33	13	Contacted	0.375	경상남도
34	90	Contacted	0.175	충청북도
35	40	Healthy	0.0	경상남도
36	59	Confirmed	0.9	인천광역시
37	21	Contacted	0.3	경상남도
38	99	Confirmed	0.3	경상남도
39	20	Healthy	0.0	경기도
40	21	Confirmed	0.95	전라북도
41	76	Healthy	0.0	제주특별자치도
42	17	Contacted	0.125	서울특별시
43	10	Healthy	0.0	전라북도
44	50	Contacted	0.45	인천광역시
45	58	Contacted	0.175	서울특별시
46	44	Confirmed	0.6	경상남도

47	1	Confirmed	0.75	강원도
48	94	Healthy	0.0	강원도
49	96	Healthy	0.0	울산광역시
50	96	Healthy	0.0	대전광역시
51	25	Healthy	0.0	전라북도
52	68	Contacted	0.375	강원도
53	59	Confirmed	0.3	경상북도
54	50	Confirmed	0.9	전라북도
55	13	Contacted	0.225	경상북도
56	76	Contacted	0.45	광주광역시
57	48	Contacted	0.3	부산광역시
58	53	Healthy	0.0	전라북도
59	12	Confirmed	0.85	서울특별시
60	43	Contacted	0.125	경상북도
61	54	Contacted	0.275	울산광역시
62	52	Confirmed	0.45	제주특별자치도
63	31	Confirmed	0.7	제주특별자치도
64	28	Contacted	0.275	전라남도
65	40	Contacted	0.2	경상남도
66	88	Confirmed	0.5	경기도
67	27	Contacted	0.275	충청남도
68	40	Confirmed	0.45	전라북도
69	66	Contacted	0.225	서울특별시
70	49	Contacted	0.375	충청남도
71	82	Healthy	0.0	광주광역시
72	7	Healthy	0.0	전라남도
73	78	Healthy	0.0	서울특별시
74	30	Contacted	0.325	서울특별시
75	87	Contacted	0.325	전라남도
76	72	Contacted	0.375	경상북도
77	67	Confirmed	0.35	서울특별시
78	16	Healthy	0.0	경기도
79	62	Contacted	0.45	전라북도
80	24	Healthy	0.0	경상북도
81	10	Confirmed	0.55	대구광역시
82	72	Confirmed	0.85	인천광역시
83	70	Contacted	0.2	경기도
84	30	Confirmed	0.6	경기도
85	37	Healthy	0.0	경상북도
86	23	Contacted	0.15	전라북도
87	13	Confirmed	0.55	경상남도
88	34	Confirmed	0.25	대구광역시
89	19	Confirmed	0.25	충청북도
90	12	Healthy	0.0	전라남도

```
91  88  Healthy      0.0      대구광역시
92  80  Healthy      0.0      충청북도
93  13  Healthy      0.0      서울특별시
94  46  Confirmed    0.65     서울특별시
95  49  Contacted    0.325    서울특별시
96  15  Confirmed    0.25     경기도
97  37  Confirmed    0.65     경기도
98  40  Healthy      0.0      경상남도
99  65  Confirmed    0.55     충청북도
100 45  Confirmed    0.65     충청남도

Number of healthy people: 33
Number of contacted people: 33
Number of confirmed people: 34
Average Severity of contacted people: 0.28
Average Severity of confirmed people: 0.57

Number of Clusters: 2
    Cluster 0:
        Number of People: 64
        Average of severities: 0.12
        The Coordinates of Centroid:
            X1 (Severity): 0.12

    Cluster 1:
        Number of People: 36
        Average of severities: 0.58
        The Coordinates of Centroid:
            X1 (Severity): 0.58

    -------------------------------------------------
     Cluster ID | # of People | Avg. of Severity
              0 |          64 |          0.12
              1 |          36 |          0.58
    ------------|-------------|------------------
       Total    |         100 |
        SSE     |        2.29 |
    -------------------------------------------------

Number of Clusters: 3
    Cluster 0:
        Number of People: 44
        Average of severities: 0.32
        The Coordinates of Centroid:
            X1 (Severity): 0.32

    Cluster 1:
        Number of People: 19
```

```
        Average of severities: 0.72
        The Coordinates of Centroid:
            X1 (Severity): 0.72

    Cluster 2:
        Number of People: 37
        Average of severities: 0.01
        The Coordinates of Centroid:
            X1 (Severity): 0.01

    ------------------------------------------------
     Cluster ID | # of People | Avg. of Severity
              0 |          44 |           0.32
              1 |          19 |           0.72
              2 |          37 |           0.01
    ------------|-------------|-----------------
       Total    |         100 |
        SSE     |        0.82 |
    ------------------------------------------------

Number of Clusters: 4
    Cluster 0:
        Number of People: 35
        Average of severities: 0.28
        The Coordinates of Centroid:
            X1 (Severity): 0.28

    Cluster 1:
        Number of People: 21
        Average of severities: 0.54
        The Coordinates of Centroid:
            X1 (Severity): 0.54

    Cluster 2:
        Number of People: 36
        Average of severities: 0.01
        The Coordinates of Centroid:
            X1 (Severity): 0.01

    Cluster 3:
        Number of People: 8
        Average of severities: 0.88
        The Coordinates of Centroid:
            X1 (Severity): 0.87

    ------------------------------------------------
     Cluster ID | # of People | Avg. of Severity
              0 |          35 |           0.28
              1 |          21 |           0.54
```

```
            2 |          36 |          0.01
            3 |           8 |          0.88
    ------------|-------------|------------------
       Total    |         100 |
        SSE     |        0.37 |
    ------------------------------------------------

Number of Clusters: 5
    Cluster 0:
        Number of People: 36
        Average of severities: 0.01
        The Coordinates of Centroid:
            X1 (Severity): 0.01

    Cluster 1:
        Number of People: 28
        Average of severities: 0.26
        The Coordinates of Centroid:
            X1 (Severity): 0.26

    Cluster 2:
        Number of People: 8
        Average of severities: 0.88
        The Coordinates of Centroid:
            X1 (Severity): 0.87

    Cluster 3:
        Number of People: 17
        Average of severities: 0.42
        The Coordinates of Centroid:
            X1 (Severity): 0.42

    Cluster 4:
        Number of People: 11
        Average of severities: 0.61
        The Coordinates of Centroid:
            X1 (Severity): 0.61

    ------------------------------------------------
     Cluster ID | # of People | Avg. of Severity
            0 |          36 |          0.01
            1 |          28 |          0.26
            2 |           8 |          0.88
            3 |          17 |          0.42
            4 |          11 |          0.61
    ------------|-------------|------------------
       Total    |         100 |
        SSE     |        0.21 |
    ------------------------------------------------
```

```
Number of Clusters: 6
    Cluster 0:
        Number of People: 33
        Average of severities: 0.0
        The Coordinates of Centroid:
            X1 (Severity): -0.0

    Cluster 1:
        Number of People: 11
        Average of severities: 0.61
        The Coordinates of Centroid:
            X1 (Severity): 0.61

    Cluster 2:
        Number of People: 15
        Average of severities: 0.43
        The Coordinates of Centroid:
            X1 (Severity): 0.43

    Cluster 3:
        Number of People: 8
        Average of severities: 0.88
        The Coordinates of Centroid:
            X1 (Severity): 0.87

    Cluster 4:
        Number of People: 13
        Average of severities: 0.18
        The Coordinates of Centroid:
            X1 (Severity): 0.18

    Cluster 5:
        Number of People: 20
        Average of severities: 0.3
        The Coordinates of Centroid:
            X1 (Severity): 0.3

    ------------------------------------------------
     Cluster ID | # of People | Avg. of Severity
              0 |          33 |           0.0
              1 |          11 |          0.61
              2 |          15 |          0.43
              3 |           8 |          0.88
              4 |          13 |          0.18
              5 |          20 |           0.3
    ------------|-------------|------------------
       Total    |         100 |
        SSE     |        0.11 |
```

```
    ------------------------------------------------

Number of Clusters: 7
    Cluster 0:
        Number of People: 13
        Average of severities: 0.18
        The Coordinates of Centroid:
            X1 (Severity): 0.18

    Cluster 1:
        Number of People: 6
        Average of severities: 0.67
        The Coordinates of Centroid:
            X1 (Severity): 0.68

    Cluster 2:
        Number of People: 13
        Average of severities: 0.42
        The Coordinates of Centroid:
            X1 (Severity): 0.42

    Cluster 3:
        Number of People: 33
        Average of severities: 0.0
        The Coordinates of Centroid:
            X1 (Severity): -0.0

    Cluster 4:
        Number of People: 7
        Average of severities: 0.89
        The Coordinates of Centroid:
            X1 (Severity): 0.89

    Cluster 5:
        Number of People: 20
        Average of severities: 0.3
        The Coordinates of Centroid:
            X1 (Severity): 0.3

    Cluster 6:
        Number of People: 8
        Average of severities: 0.55
        The Coordinates of Centroid:
            X1 (Severity): 0.55

    ------------------------------------------------
     Cluster ID | # of People | Avg. of Severity
              0 |          13 |           0.18
              1 |           6 |           0.67
```

```
             2 |          13 |          0.42
             3 |          33 |           0.0
             4 |           7 |          0.89
             5 |          20 |           0.3
             6 |           8 |          0.55
    -----------|-------------|-----------------
       Total   |         100 |
        SSE    |        0.08 |
    ------------------------------------------------

Number of Clusters: 8
    Cluster 0:
        Number of People: 14
        Average of severities: 0.28
        The Coordinates of Centroid:
            X1 (Severity): 0.28

    Cluster 1:
        Number of People: 10
        Average of severities: 0.46
        The Coordinates of Centroid:
            X1 (Severity): 0.46

    Cluster 2:
        Number of People: 33
        Average of severities: 0.0
        The Coordinates of Centroid:
            X1 (Severity): -0.0

    Cluster 3:
        Number of People: 7
        Average of severities: 0.89
        The Coordinates of Centroid:
            X1 (Severity): 0.89

    Cluster 4:
        Number of People: 6
        Average of severities: 0.67
        The Coordinates of Centroid:
            X1 (Severity): 0.68

    Cluster 5:
        Number of People: 13
        Average of severities: 0.18
        The Coordinates of Centroid:
            X1 (Severity): 0.18

    Cluster 6:
        Number of People: 6
```

```
        Average of severities: 0.57
        The Coordinates of Centroid:
            X1 (Severity): 0.57

    Cluster 7:
        Number of People: 11
        Average of severities: 0.35
        The Coordinates of Centroid:
            X1 (Severity): 0.35

    ------------------------------------------------
     Cluster ID | # of People | Avg. of Severity
              0 |          14 |          0.28
              1 |          10 |          0.46
              2 |          33 |           0.0
              3 |           7 |          0.89
              4 |           6 |          0.67
              5 |          13 |          0.18
              6 |           6 |          0.57
              7 |          11 |          0.35
    ------------|-------------|------------------
       Total    |         100 |
        SSE     |        0.05 |
    ------------------------------------------------

Number of Clusters: 9
    Cluster 0:
        Number of People: 15
        Average of severities: 0.3
        The Coordinates of Centroid:
            X1 (Severity): 0.3

    Cluster 1:
        Number of People: 6
        Average of severities: 0.67
        The Coordinates of Centroid:
            X1 (Severity): 0.68

    Cluster 2:
        Number of People: 33
        Average of severities: 0.0
        The Coordinates of Centroid:
            X1 (Severity): -0.0

    Cluster 3:
        Number of People: 10
        Average of severities: 0.46
        The Coordinates of Centroid:
            X1 (Severity): 0.46
```

```
Cluster 4:
    Number of People: 7
    Average of severities: 0.89
    The Coordinates of Centroid:
        X1 (Severity): 0.89

Cluster 5:
    Number of People: 7
    Average of severities: 0.15
    The Coordinates of Centroid:
        X1 (Severity): 0.15

Cluster 6:
    Number of People: 6
    Average of severities: 0.57
    The Coordinates of Centroid:
        X1 (Severity): 0.57

Cluster 7:
    Number of People: 7
    Average of severities: 0.37
    The Coordinates of Centroid:
        X1 (Severity): 0.37

Cluster 8:
    Number of People: 9
    Average of severities: 0.22
    The Coordinates of Centroid:
        X1 (Severity): 0.22

-------------------------------------------------
 Cluster ID | # of People | Avg. of Severity
          0 |          15 |           0.3
          1 |           6 |          0.67
          2 |          33 |           0.0
          3 |          10 |          0.46
          4 |           7 |          0.89
          5 |           7 |          0.15
          6 |           6 |          0.57
          7 |           7 |          0.37
          8 |           9 |          0.22
------------|-------------|------------------
   Total    |         100 |
    SSE     |        0.04 |
-------------------------------------------------
```

3. Result of Clustering with Multiple Feature

3.1. Clustering using Scikit-Learn Library

3.1.1. Clustering using K-means

- **Used Columns: Age, Severity**
- **Distance Function: Euclidean Distance**
- **Console window results**

```
Total number of People: 100
ID  Age Covid Status Severity Address
1   72  Contacted    0.125    충청남도
2   50  Healthy      0.0      경기도
3   49  Contacted    0.2      경상북도
4   45  Contacted    0.225    전라남도
5   45  Contacted    0.325    전라남도
6   66  Confirmed    0.55     부산광역시
7   86  Healthy      0.0      전라남도
8   43  Healthy      0.0      서울특별시
9   63  Healthy      0.0      경기도
10  81  Confirmed    0.35     광주광역시
11  2   Contacted    0.175    경상북도
12  69  Healthy      0.0      전라북도
13  66  Healthy      0.0      전라북도
14  37  Contacted    0.425    울산광역시
15  97  Healthy      0.0      경상북도
16  98  Healthy      0.0      경상북도
17  56  Confirmed    0.65     전라북도
18  26  Contacted    0.3      경상남도
19  90  Confirmed    0.9      전라북도
20  21  Confirmed    0.5      전라북도
21  26  Healthy      0.0      경상북도
22  17  Confirmed    0.45     제주특별자치도
23  55  Healthy      0.0      부산광역시
24  74  Healthy      0.0      경상북도
25  91  Contacted    0.275    경상북도
26  33  Healthy      0.0      대전광역시
27  1   Healthy      0.0      강원도
28  91  Confirmed    0.9      전라남도
29  74  Confirmed    0.45     전라남도
30  52  Contacted    0.275    경기도
31  49  Confirmed    0.4      전라남도
32  49  Confirmed    0.3      전라남도
```

33	13	Contacted	0.375	경상남도
34	90	Contacted	0.175	충청북도
35	40	Healthy	0.0	경상남도
36	59	Confirmed	0.9	인천광역시
37	21	Contacted	0.3	경상남도
38	99	Confirmed	0.3	경상남도
39	20	Healthy	0.0	경기도
40	21	Confirmed	0.95	전라북도
41	76	Healthy	0.0	제주특별자치도
42	17	Contacted	0.125	서울특별시
43	10	Healthy	0.0	전라북도
44	50	Contacted	0.45	인천광역시
45	58	Contacted	0.175	서울특별시
46	44	Confirmed	0.6	경상남도
47	1	Confirmed	0.75	강원도
48	94	Healthy	0.0	강원도
49	96	Healthy	0.0	울산광역시
50	96	Healthy	0.0	대전광역시
51	25	Healthy	0.0	전라북도
52	68	Contacted	0.375	강원도
53	59	Confirmed	0.3	경상북도
54	50	Confirmed	0.9	전라북도
55	13	Contacted	0.225	경상북도
56	76	Contacted	0.45	광주광역시
57	48	Contacted	0.3	부산광역시
58	53	Healthy	0.0	전라북도
59	12	Confirmed	0.85	서울특별시
60	43	Contacted	0.125	경상북도
61	54	Contacted	0.275	울산광역시
62	52	Confirmed	0.45	제주특별자치도
63	31	Confirmed	0.7	제주특별자치도
64	28	Contacted	0.275	전라남도
65	40	Contacted	0.2	경상남도
66	88	Confirmed	0.5	경기도
67	27	Contacted	0.275	충청남도
68	40	Confirmed	0.45	전라북도
69	66	Contacted	0.225	서울특별시
70	49	Contacted	0.375	충청남도
71	82	Healthy	0.0	광주광역시
72	7	Healthy	0.0	전라남도
73	78	Healthy	0.0	서울특별시
74	30	Contacted	0.325	서울특별시
75	87	Contacted	0.325	전라남도
76	72	Contacted	0.375	경상북도

```
77  67  Confirmed    0.35     서울특별시
78  16  Healthy      0.0      경기도
79  62  Contacted    0.45     전라북도
80  24  Healthy      0.0      경상북도
81  10  Confirmed    0.55     대구광역시
82  72  Confirmed    0.85     인천광역시
83  70  Contacted    0.2      경기도
84  30  Confirmed    0.6      경기도
85  37  Healthy      0.0      경상북도
86  23  Contacted    0.15     전라북도
87  13  Confirmed    0.55     경상남도
88  34  Confirmed    0.25     대구광역시
89  19  Confirmed    0.25     충청북도
90  12  Healthy      0.0      전라남도
91  88  Healthy      0.0      대구광역시
92  80  Healthy      0.0      충청북도
93  13  Healthy      0.0      서울특별시
94  46  Confirmed    0.65     서울특별시
95  49  Contacted    0.325    서울특별시
96  15  Confirmed    0.25     경기도
97  37  Confirmed    0.65     경기도
98  40  Healthy      0.0      경상남도
99  65  Confirmed    0.55     충청북도
100 45  Confirmed    0.65     충청남도

Number of healthy people: 33
Number of contacted people: 33
Number of confirmed people: 34
Average Severity of contacted people: 0.28
Average Severity of confirmed people: 0.57

Number of Clusters: 2
    Cluster 0:
        Number of People: 31
        Average of Age: 45.74
        Average of severities: 0.61
        The Coordinates of Centroid:
            X1 (Severity): 0.65
            X2 (Age): 0.46

    Cluster 1:
        Number of People: 69
        Average of Age: 50.81
        Average of severities: 0.14
        The Coordinates of Centroid:
            X1 (Severity): 0.14
            X2 (Age): 0.51
```

```
    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          31 |         45.74 |           0.61
              1 |          69 |         50.81 |           0.14
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |       28.95 |
    ------------------------------------------------------------

Number of Clusters: 3
    Cluster 0:
        Number of People: 45
        Average of Age: 28.58
        Average of severities: 0.19
        The Coordinates of Centroid:
            X1 (Severity): 0.2
            X2 (Age): 0.28

    Cluster 1:
        Number of People: 25
        Average of Age: 52.28
        Average of severities: 0.65
        The Coordinates of Centroid:
            X1 (Severity): 0.68
            X2 (Age): 0.52

    Cluster 2:
        Number of People: 30
        Average of Age: 77.7
        Average of severities: 0.12
        The Coordinates of Centroid:
            X1 (Severity): 0.12
            X2 (Age): 0.78

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          45 |         28.58 |           0.19
              1 |          25 |         52.28 |           0.65
              2 |          30 |          77.7 |           0.12
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |       22.45 |
    ------------------------------------------------------------

Number of Clusters: 4
    Cluster 0:
        Number of People: 22
        Average of Age: 80.59
```

```
        Average of severities: 0.05
        The Coordinates of Centroid:
            X1 (Severity): 0.05
            X2 (Age): 0.81

    Cluster 1:
        Number of People: 17
        Average of Age: 33.24
        Average of severities: 0.69
        The Coordinates of Centroid:
            X1 (Severity): 0.73
            X2 (Age): 0.33

    Cluster 2:
        Number of People: 32
        Average of Age: 24.78
        Average of severities: 0.12
        The Coordinates of Centroid:
            X1 (Severity): 0.13
            X2 (Age): 0.24

    Cluster 3:
        Number of People: 29
        Average of Age: 61.83
        Average of severities: 0.41
        The Coordinates of Centroid:
            X1 (Severity): 0.43
            X2 (Age): 0.62

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          22 |         80.59 |           0.05
              1 |          17 |         33.24 |           0.69
              2 |          32 |         24.78 |           0.12
              3 |          29 |         61.83 |           0.41
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |       18.74 |
    ------------------------------------------------------------

Number of Clusters: 5
    Cluster 0:
        Number of People: 26
        Average of Age: 45.42
        Average of severities: 0.21
        The Coordinates of Centroid:
            X1 (Severity): 0.22
            X2 (Age): 0.45
```

```
    Cluster 1:
        Number of People: 20
        Average of Age: 64.65
        Average of severities: 0.6
        The Coordinates of Centroid:
            X1 (Severity): 0.63
            X2 (Age): 0.65

    Cluster 2:
        Number of People: 22
        Average of Age: 83.32
        Average of severities: 0.08
        The Coordinates of Centroid:
            X1 (Severity): 0.08
            X2 (Age): 0.84

    Cluster 3:
        Number of People: 13
        Average of Age: 21.77
        Average of severities: 0.6
        The Coordinates of Centroid:
            X1 (Severity): 0.63
            X2 (Age): 0.21

    Cluster 4:
        Number of People: 19
        Average of Age: 17.58
        Average of severities: 0.08
        The Coordinates of Centroid:
            X1 (Severity): 0.08
            X2 (Age): 0.17

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          26 |         45.42 |           0.21
              1 |          20 |         64.65 |            0.6
              2 |          22 |         83.32 |           0.08
              3 |          13 |         21.77 |            0.6
              4 |          19 |         17.58 |           0.08
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |       17.34 |
    ------------------------------------------------------------

Number of Clusters: 6
    Cluster 0:
        Number of People: 22
        Average of Age: 82.64
        Average of severities: 0.07
```

```
        The Coordinates of Centroid:
            X1 (Severity): 0.08
            X2 (Age): 0.83

    Cluster 1:
        Number of People: 10
        Average of Age: 19.3
        Average of severities: 0.65
        The Coordinates of Centroid:
            X1 (Severity): 0.69
            X2 (Age): 0.19

    Cluster 2:
        Number of People: 5
        Average of Age: 72.4
        Average of severities: 0.89
        The Coordinates of Centroid:
            X1 (Severity): 0.94
            X2 (Age): 0.73

    Cluster 3:
        Number of People: 18
        Average of Age: 15.39
        Average of severities: 0.1
        The Coordinates of Centroid:
            X1 (Severity): 0.11
            X2 (Age): 0.15

    Cluster 4:
        Number of People: 24
        Average of Age: 42.83
        Average of severities: 0.17
        The Coordinates of Centroid:
            X1 (Severity): 0.18
            X2 (Age): 0.43

    Cluster 5:
        Number of People: 21
        Average of Age: 59.33
        Average of severities: 0.47
        The Coordinates of Centroid:
            X1 (Severity): 0.49
            X2 (Age): 0.6

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          22 |         82.64 |           0.07
              1 |          10 |          19.3 |           0.65
              2 |           5 |          72.4 |           0.89
```

```
             3 |          18 |        15.39 |           0.1
             4 |          24 |        42.83 |          0.17
             5 |          21 |        59.33 |          0.47
    -----------|-------------|---------------|-----------------
       Total   |         100 |
        SSE    |       15.92 |
    ------------------------------------------------------------

Number of Clusters: 7
    Cluster 0:
        Number of People: 11
        Average of Age: 62.18
        Average of severities: 0.74
        The Coordinates of Centroid:
            X1 (Severity): 0.78
            X2 (Age): 0.62

    Cluster 1:
        Number of People: 18
        Average of Age: 21.61
        Average of severities: 0.02
        The Coordinates of Centroid:
            X1 (Severity): 0.03
            X2 (Age): 0.21

    Cluster 2:
        Number of People: 17
        Average of Age: 82.65
        Average of severities: 0.02
        The Coordinates of Centroid:
            X1 (Severity): 0.02
            X2 (Age): 0.83

    Cluster 3:
        Number of People: 12
        Average of Age: 77.92
        Average of severities: 0.37
        The Coordinates of Centroid:
            X1 (Severity): 0.39
            X2 (Age): 0.78

    Cluster 4:
        Number of People: 15
        Average of Age: 22.0
        Average of severities: 0.37
        The Coordinates of Centroid:
            X1 (Severity): 0.39
            X2 (Age): 0.21
```

```
    Cluster 5:
        Number of People: 6
        Average of Age: 22.0
        Average of severities: 0.75
        The Coordinates of Centroid:
            X1 (Severity): 0.79
            X2 (Age): 0.21

    Cluster 6:
        Number of People: 21
        Average of Age: 49.95
        Average of severities: 0.25
        The Coordinates of Centroid:
            X1 (Severity): 0.26
            X2 (Age): 0.5

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          11 |         62.18 |           0.74
              1 |          18 |         21.61 |           0.02
              2 |          17 |         82.65 |           0.02
              3 |          12 |         77.92 |           0.37
              4 |          15 |          22.0 |           0.37
              5 |           6 |          22.0 |           0.75
              6 |          21 |         49.95 |           0.25
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |       13.99 |
    ------------------------------------------------------------

Number of Clusters: 8
    Cluster 0:
        Number of People: 11
        Average of Age: 52.27
        Average of severities: 0.53
        The Coordinates of Centroid:
            X1 (Severity): 0.56
            X2 (Age): 0.52

    Cluster 1:
        Number of People: 20
        Average of Age: 19.65
        Average of severities: 0.06
        The Coordinates of Centroid:
            X1 (Severity): 0.06
            X2 (Age): 0.19

    Cluster 2:
        Number of People: 12
```

```
        Average of Age: 61.58
        Average of severities: 0.06
        The Coordinates of Centroid:
            X1 (Severity): 0.06
            X2 (Age): 0.62

    Cluster 3:
        Number of People: 19
        Average of Age: 41.32
        Average of severities: 0.28
        The Coordinates of Centroid:
            X1 (Severity): 0.3
            X2 (Age): 0.41

    Cluster 4:
        Number of People: 11
        Average of Age: 18.73
        Average of severities: 0.63
        The Coordinates of Centroid:
            X1 (Severity): 0.66
            X2 (Age): 0.18

    Cluster 5:
        Number of People: 12
        Average of Age: 88.42
        Average of severities: 0.01
        The Coordinates of Centroid:
            X1 (Severity): 0.02
            X2 (Age): 0.89

    Cluster 6:
        Number of People: 10
        Average of Age: 80.3
        Average of severities: 0.38
        The Coordinates of Centroid:
            X1 (Severity): 0.39
            X2 (Age): 0.81

    Cluster 7:
        Number of People: 5
        Average of Age: 72.4
        Average of severities: 0.89
        The Coordinates of Centroid:
            X1 (Severity): 0.94
            X2 (Age): 0.73

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          11 |         52.27 |            0.53
```

```
             1 |          20 |         19.65 |           0.06
             2 |          12 |         61.58 |           0.06
             3 |          19 |         41.32 |           0.28
             4 |          11 |         18.73 |           0.63
             5 |          12 |         88.42 |           0.01
             6 |          10 |          80.3 |           0.38
             7 |           5 |          72.4 |           0.89
    ------------|-------------|---------------|------------------
       Total    |         100 |
        SSE     |       13.05 |
    ------------------------------------------------------------

Number of Clusters: 9
    Cluster 0:
        Number of People: 11
        Average of Age: 92.45
        Average of severities: 0.07
        The Coordinates of Centroid:
            X1 (Severity): 0.07
            X2 (Age): 0.93

    Cluster 1:
        Number of People: 13
        Average of Age: 19.46
        Average of severities: 0.36
        The Coordinates of Centroid:
            X1 (Severity): 0.37
            X2 (Age): 0.19

    Cluster 2:
        Number of People: 11
        Average of Age: 73.27
        Average of severities: 0.43
        The Coordinates of Centroid:
            X1 (Severity): 0.45
            X2 (Age): 0.74

    Cluster 3:
        Number of People: 4
        Average of Age: 78.0
        Average of severities: 0.89
        The Coordinates of Centroid:
            X1 (Severity): 0.93
            X2 (Age): 0.79

    Cluster 4:
        Number of People: 9
        Average of Age: 43.78
        Average of severities: 0.01
```

```
        The Coordinates of Centroid:
            X1 (Severity): 0.01
            X2 (Age): 0.44

    Cluster 5:
        Number of People: 11
        Average of Age: 70.18
        Average of severities: 0.07
        The Coordinates of Centroid:
            X1 (Severity): 0.07
            X2 (Age): 0.71

    Cluster 6:
        Number of People: 13
        Average of Age: 15.08
        Average of severities: 0.03
        The Coordinates of Centroid:
            X1 (Severity): 0.04
            X2 (Age): 0.14

    Cluster 7:
        Number of People: 11
        Average of Age: 33.91
        Average of severities: 0.72
        The Coordinates of Centroid:
            X1 (Severity): 0.76
            X2 (Age): 0.34

    Cluster 8:
        Number of People: 17
        Average of Age: 47.12
        Average of severities: 0.32
        The Coordinates of Centroid:
            X1 (Severity): 0.34
            X2 (Age): 0.47

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          11 |         92.45 |           0.07
              1 |          13 |         19.46 |           0.36
              2 |          11 |         73.27 |           0.43
              3 |           4 |          78.0 |           0.89
              4 |           9 |         43.78 |           0.01
              5 |          11 |         70.18 |           0.07
              6 |          13 |         15.08 |           0.03
              7 |          11 |         33.91 |           0.72
              8 |          17 |         47.12 |           0.32
    ------------|-------------|---------------|-----------------
       Total    |         100 |
```

```
        SSE      |       11.49 |
    ------------------------------------------------------------
```

3.2. Clustering using Pyclustering Library

3.2.1. K-means Algorithm Using Custom Distance Function 1

❑ **Used Columns: Age, Severity**

❑ **Distance Function: Weighted Euclidean Distance**

When forming a cluster, the weight of a specific column is weighted, and the effect of the column value is greater.

❍ Code of weighted Euclidean distance function

Weight of first column (Severity): 0.9

Weight of second column (Age): 0.1

```
def weighted_euclidean_distance(point1, point2):
    # point 1 is data.
    # point 2 is centroid

    # 0.9 for first feature and 0.1 for second feature
    weights_list = [0.9, 0.1]
    distance = 0.0

    if len(point1) == 2:  # when calculating the distance of two coordinates
        for i in range(len(point1)):
            distance += weights_list[i] * (point1[i] - point2[i]) ** 2.0
    else:  # when updating Centroid
        for i in range(len(point1)):
            distance += (point1[i] - point2[i]) ** 2.0

    return distance ** 0.5
```

❑ **Console window results**

```
Total number of People: 100
ID  Age Covid Status Severity Address
1   72  Contacted    0.125    충청남도
2   50  Healthy      0.0      경기도
3   49  Contacted    0.2      경상북도
4   45  Contacted    0.225    전라남도
5   45  Contacted    0.325    전라남도
6   66  Confirmed    0.55     부산광역시
7   86  Healthy      0.0      전라남도
8   43  Healthy      0.0      서울특별시
9   63  Healthy      0.0      경기도
10  81  Confirmed    0.35     광주광역시
11  2   Contacted    0.175    경상북도
12  69  Healthy      0.0      전라북도
```

13	66	Healthy	0.0	전라북도
14	37	Contacted	0.425	울산광역시
15	97	Healthy	0.0	경상북도
16	98	Healthy	0.0	경상북도
17	56	Confirmed	0.65	전라북도
18	26	Contacted	0.3	경상남도
19	90	Confirmed	0.9	전라북도
20	21	Confirmed	0.5	전라북도
21	26	Healthy	0.0	경상북도
22	17	Confirmed	0.45	제주특별자치도
23	55	Healthy	0.0	부산광역시
24	74	Healthy	0.0	경상북도
25	91	Contacted	0.275	경상북도
26	33	Healthy	0.0	대전광역시
27	1	Healthy	0.0	강원도
28	91	Confirmed	0.9	전라남도
29	74	Confirmed	0.45	전라남도
30	52	Contacted	0.275	경기도
31	49	Confirmed	0.4	전라남도
32	49	Confirmed	0.3	전라남도
33	13	Contacted	0.375	경상남도
34	90	Contacted	0.175	충청북도
35	40	Healthy	0.0	경상남도
36	59	Confirmed	0.9	인천광역시
37	21	Contacted	0.3	경상남도
38	99	Confirmed	0.3	경상남도
39	20	Healthy	0.0	경기도
40	21	Confirmed	0.95	전라북도
41	76	Healthy	0.0	제주특별자치도
42	17	Contacted	0.125	서울특별시
43	10	Healthy	0.0	전라북도
44	50	Contacted	0.45	인천광역시
45	58	Contacted	0.175	서울특별시
46	44	Confirmed	0.6	경상남도
47	1	Confirmed	0.75	강원도
48	94	Healthy	0.0	강원도
49	96	Healthy	0.0	울산광역시
50	96	Healthy	0.0	대전광역시
51	25	Healthy	0.0	전라북도
52	68	Contacted	0.375	강원도
53	59	Confirmed	0.3	경상북도
54	50	Confirmed	0.9	전라북도
55	13	Contacted	0.225	경상북도
56	76	Contacted	0.45	광주광역시

57	48	Contacted	0.3	부산광역시
58	53	Healthy	0.0	전라북도
59	12	Confirmed	0.85	서울특별시
60	43	Contacted	0.125	경상북도
61	54	Contacted	0.275	울산광역시
62	52	Confirmed	0.45	제주특별자치도
63	31	Confirmed	0.7	제주특별자치도
64	28	Contacted	0.275	전라남도
65	40	Contacted	0.2	경상남도
66	88	Confirmed	0.5	경기도
67	27	Contacted	0.275	충청남도
68	40	Confirmed	0.45	전라북도
69	66	Contacted	0.225	서울특별시
70	49	Contacted	0.375	충청남도
71	82	Healthy	0.0	광주광역시
72	7	Healthy	0.0	전라남도
73	78	Healthy	0.0	서울특별시
74	30	Contacted	0.325	서울특별시
75	87	Contacted	0.325	전라남도
76	72	Contacted	0.375	경상북도
77	67	Confirmed	0.35	서울특별시
78	16	Healthy	0.0	경기도
79	62	Contacted	0.45	전라북도
80	24	Healthy	0.0	경상북도
81	10	Confirmed	0.55	대구광역시
82	72	Confirmed	0.85	인천광역시
83	70	Contacted	0.2	경기도
84	30	Confirmed	0.6	경기도
85	37	Healthy	0.0	경상북도
86	23	Contacted	0.15	전라북도
87	13	Confirmed	0.55	경상남도
88	34	Confirmed	0.25	대구광역시
89	19	Confirmed	0.25	충청북도
90	12	Healthy	0.0	전라남도
91	88	Healthy	0.0	대구광역시
92	80	Healthy	0.0	충청북도
93	13	Healthy	0.0	서울특별시
94	46	Confirmed	0.65	서울특별시
95	49	Contacted	0.325	서울특별시
96	15	Confirmed	0.25	경기도
97	37	Confirmed	0.65	경기도
98	40	Healthy	0.0	경상남도
99	65	Confirmed	0.55	충청북도
100	45	Confirmed	0.65	충청남도

```
Number of healthy people: 33
Number of contacted people: 33
Number of confirmed people: 34
Average Severity of contacted people: 0.28
Average Severity of confirmed people: 0.57

Number of Clusters: 2
    Cluster 0:
        Number of People: 64
        Average of Age: 49.52
        Average of severities: 0.12
        The Coordinates of Centroid:
            X1 (Severity): 0.12
            X2 (Age): 0.5

    Cluster 1:
        Number of People: 36
        Average of Age: 48.75
        Average of severities: 0.58
        The Coordinates of Centroid:
            X1 (Severity): 0.61
            X2 (Age): 0.49

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          64 |         49.52 |             0.12
              1 |          36 |         48.75 |             0.58
    ------------|-------------|---------------|------------------
       Total    |         100 |
        SSE     |       16.13 |
    ------------------------------------------------------------

Number of Clusters: 3
    Cluster 0:
        Number of People: 44
        Average of Age: 49.59
        Average of severities: 0.32
        The Coordinates of Centroid:
            X1 (Severity): 0.34
            X2 (Age): 0.5

    Cluster 1:
        Number of People: 37
        Average of Age: 51.43
        Average of severities: 0.01
        The Coordinates of Centroid:
            X1 (Severity): 0.01
            X2 (Age): 0.51
```

```
    Cluster 2:
        Number of People: 19
        Average of Age: 44.16
        Average of severities: 0.72
        The Coordinates of Centroid:
            X1 (Severity): 0.76
            X2 (Age): 0.44

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          44 |         49.59 |             0.32
              1 |          37 |         51.43 |             0.01
              2 |          19 |         44.16 |             0.72
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |       11.24 |
    ------------------------------------------------------------

Number of Clusters: 4
    Cluster 0:
        Number of People: 20
        Average of Age: 24.1
        Average of severities: 0.03
        The Coordinates of Centroid:
            X1 (Severity): 0.03
            X2 (Age): 0.24

    Cluster 1:
        Number of People: 19
        Average of Age: 79.63
        Average of severities: 0.02
        The Coordinates of Centroid:
            X1 (Severity): 0.02
            X2 (Age): 0.8

    Cluster 2:
        Number of People: 42
        Average of Age: 49.76
        Average of severities: 0.33
        The Coordinates of Centroid:
            X1 (Severity): 0.35
            X2 (Age): 0.5

    Cluster 3:
        Number of People: 19
        Average of Age: 44.16
        Average of severities: 0.72
        The Coordinates of Centroid:
```

```
            X1 (Severity): 0.76
            X2 (Age): 0.44

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          20 |          24.1 |             0.03
              1 |          19 |         79.63 |             0.02
              2 |          42 |         49.76 |             0.33
              3 |          19 |         44.16 |             0.72
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |        9.62 |
    ------------------------------------------------------------

Number of Clusters: 5
    Cluster 0:
        Number of People: 20
        Average of Age: 24.1
        Average of severities: 0.03
        The Coordinates of Centroid:
            X1 (Severity): 0.03
            X2 (Age): 0.24

    Cluster 1:
        Number of People: 19
        Average of Age: 79.63
        Average of severities: 0.02
        The Coordinates of Centroid:
            X1 (Severity): 0.02
            X2 (Age): 0.8

    Cluster 2:
        Number of People: 27
        Average of Age: 48.96
        Average of severities: 0.27
        The Coordinates of Centroid:
            X1 (Severity): 0.29
            X2 (Age): 0.49

    Cluster 3:
        Number of People: 21
        Average of Age: 47.43
        Average of severities: 0.47
        The Coordinates of Centroid:
            X1 (Severity): 0.49
            X2 (Age): 0.47

    Cluster 4:
        Number of People: 13
```

```
        Average of Age: 47.0
        Average of severities: 0.79
        The Coordinates of Centroid:
            X1 (Severity): 0.83
            X2 (Age): 0.47

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          20 |          24.1 |             0.03
              1 |          19 |         79.63 |             0.02
              2 |          27 |         48.96 |             0.27
              3 |          21 |         47.43 |             0.47
              4 |          13 |          47.0 |             0.79
    ------------|-------------|---------------|------------------
       Total    |         100 |
        SSE     |        8.27 |
    ------------------------------------------------------------

Number of Clusters: 6
    Cluster 0:
        Number of People: 18
        Average of Age: 25.39
        Average of severities: 0.01
        The Coordinates of Centroid:
            X1 (Severity): 0.01
            X2 (Age): 0.25

    Cluster 1:
        Number of People: 18
        Average of Age: 79.06
        Average of severities: 0.01
        The Coordinates of Centroid:
            X1 (Severity): 0.01
            X2 (Age): 0.8

    Cluster 2:
        Number of People: 13
        Average of Age: 74.0
        Average of severities: 0.28
        The Coordinates of Centroid:
            X1 (Severity): 0.3
            X2 (Age): 0.74

    Cluster 3:
        Number of People: 20
        Average of Age: 31.4
        Average of severities: 0.27
        The Coordinates of Centroid:
            X1 (Severity): 0.28
```

```
            X2 (Age): 0.31

    Cluster 4:
        Number of People: 18
        Average of Age: 46.83
        Average of severities: 0.49
        The Coordinates of Centroid:
            X1 (Severity): 0.51
            X2 (Age): 0.47

    Cluster 5:
        Number of People: 13
        Average of Age: 47.0
        Average of severities: 0.79
        The Coordinates of Centroid:
            X1 (Severity): 0.83
            X2 (Age): 0.47

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          18 |         25.39 |             0.01
              1 |          18 |         79.06 |             0.01
              2 |          13 |          74.0 |             0.28
              3 |          20 |          31.4 |             0.27
              4 |          18 |         46.83 |             0.49
              5 |          13 |          47.0 |             0.79
    ------------|-------------|---------------|------------------
       Total    |         100 |
        SSE     |        7.51 |
    ------------------------------------------------------------

Number of Clusters: 7
    Cluster 0:
        Number of People: 16
        Average of Age: 24.81
        Average of severities: 0.0
        The Coordinates of Centroid:
            X1 (Severity): 0.0
            X2 (Age): 0.24

    Cluster 1:
        Number of People: 17
        Average of Age: 79.47
        Average of severities: 0.0
        The Coordinates of Centroid:
            X1 (Severity): 0.0
            X2 (Age): 0.8

    Cluster 2:
```

```
        Number of People: 12
        Average of Age: 47.92
        Average of severities: 0.18
        The Coordinates of Centroid:
            X1 (Severity): 0.18
            X2 (Age): 0.48

    Cluster 3:
        Number of People: 16
        Average of Age: 32.69
        Average of severities: 0.29
        The Coordinates of Centroid:
            X1 (Severity): 0.3
            X2 (Age): 0.32

    Cluster 4:
        Number of People: 10
        Average of Age: 72.2
        Average of severities: 0.34
        The Coordinates of Centroid:
            X1 (Severity): 0.36
            X2 (Age): 0.73

    Cluster 5:
        Number of People: 16
        Average of Age: 46.56
        Average of severities: 0.5
        The Coordinates of Centroid:
            X1 (Severity): 0.52
            X2 (Age): 0.46

    Cluster 6:
        Number of People: 13
        Average of Age: 47.0
        Average of severities: 0.79
        The Coordinates of Centroid:
            X1 (Severity): 0.83
            X2 (Age): 0.47

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          16 |         24.81 |              0.0
              1 |          17 |         79.47 |              0.0
              2 |          12 |         47.92 |             0.18
              3 |          16 |         32.69 |             0.29
              4 |          10 |          72.2 |             0.34
              5 |          16 |         46.56 |              0.5
              6 |          13 |          47.0 |             0.79
    ------------|-------------|---------------|------------------
```

```
       Total    |        100 |
        SSE     |       6.92 |
    ------------------------------------------------------------

Number of Clusters: 8
    Cluster 0:
        Number of People: 16
        Average of Age: 24.81
        Average of severities: 0.0
        The Coordinates of Centroid:
            X1 (Severity): 0.0
            X2 (Age): 0.24

    Cluster 1:
        Number of People: 17
        Average of Age: 79.47
        Average of severities: 0.0
        The Coordinates of Centroid:
            X1 (Severity): 0.0
            X2 (Age): 0.8

    Cluster 2:
        Number of People: 12
        Average of Age: 47.92
        Average of severities: 0.18
        The Coordinates of Centroid:
            X1 (Severity): 0.18
            X2 (Age): 0.48

    Cluster 3:
        Number of People: 16
        Average of Age: 35.56
        Average of severities: 0.28
        The Coordinates of Centroid:
            X1 (Severity): 0.3
            X2 (Age): 0.35

    Cluster 4:
        Number of People: 12
        Average of Age: 76.17
        Average of severities: 0.38
        The Coordinates of Centroid:
            X1 (Severity): 0.4
            X2 (Age): 0.77

    Cluster 5:
        Number of People: 10
        Average of Age: 30.2
        Average of severities: 0.46
```

```
        The Coordinates of Centroid:
            X1 (Severity): 0.48
            X2 (Age): 0.3

    Cluster 6:
        Number of People: 10
        Average of Age: 42.1
        Average of severities: 0.64
        The Coordinates of Centroid:
            X1 (Severity): 0.67
            X2 (Age): 0.42

    Cluster 7:
        Number of People: 7
        Average of Age: 56.43
        Average of severities: 0.89
        The Coordinates of Centroid:
            X1 (Severity): 0.94
            X2 (Age): 0.57

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          16 |         24.81 |            0.0
              1 |          17 |         79.47 |            0.0
              2 |          12 |         47.92 |           0.18
              3 |          16 |         35.56 |           0.28
              4 |          12 |         76.17 |           0.38
              5 |          10 |          30.2 |           0.46
              6 |          10 |          42.1 |           0.64
              7 |           7 |         56.43 |           0.89
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |        5.85 |
    ------------------------------------------------------------

Number of Clusters: 9
    Cluster 0:
        Number of People: 16
        Average of Age: 24.81
        Average of severities: 0.0
        The Coordinates of Centroid:
            X1 (Severity): 0.0
            X2 (Age): 0.24

    Cluster 1:
        Number of People: 17
        Average of Age: 79.47
        Average of severities: 0.0
        The Coordinates of Centroid:
```

```
            X1 (Severity): 0.0
            X2 (Age): 0.8

    Cluster 2:
        Number of People: 12
        Average of Age: 47.92
        Average of severities: 0.18
        The Coordinates of Centroid:
            X1 (Severity): 0.18
            X2 (Age): 0.48

    Cluster 3:
        Number of People: 15
        Average of Age: 34.0
        Average of severities: 0.28
        The Coordinates of Centroid:
            X1 (Severity): 0.3
            X2 (Age): 0.34

    Cluster 4:
        Number of People: 9
        Average of Age: 74.78
        Average of severities: 0.34
        The Coordinates of Centroid:
            X1 (Severity): 0.35
            X2 (Age): 0.75

    Cluster 5:
        Number of People: 10
        Average of Age: 30.2
        Average of severities: 0.46
        The Coordinates of Centroid:
            X1 (Severity): 0.48
            X2 (Age): 0.3

    Cluster 6:
        Number of People: 6
        Average of Age: 71.83
        Average of severities: 0.49
        The Coordinates of Centroid:
            X1 (Severity): 0.52
            X2 (Age): 0.72

    Cluster 7:
        Number of People: 8
        Average of Age: 36.25
        Average of severities: 0.66
        The Coordinates of Centroid:
            X1 (Severity): 0.69
```

```
            X2 (Age): 0.36

    Cluster 8:
        Number of People: 7
        Average of Age: 56.43
        Average of severities: 0.89
        The Coordinates of Centroid:
            X1 (Severity): 0.94
            X2 (Age): 0.57

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          16 |         24.81 |              0.0
              1 |          17 |         79.47 |              0.0
              2 |          12 |         47.92 |             0.18
              3 |          15 |          34.0 |             0.28
              4 |           9 |         74.78 |             0.34
              5 |          10 |          30.2 |             0.46
              6 |           6 |         71.83 |             0.49
              7 |           8 |         36.25 |             0.66
              8 |           7 |         56.43 |             0.89
    ------------|-------------|---------------|------------------
       Total    |         100 |
        SSE     |        5.52 |
    ------------------------------------------------------------
```

3.2.2. K-means Algorithm Using Custom Distance Function 2

- **Used Columns: Age, Severity**
- **Distance Function: Weighted Euclidean Distance**

  When forming a cluster, the weight of a specific column is weighted, and the effect of the column value is greater.

  - Code of weighted Euclidean distance function

    Weight of first column (Severity): 0.1

    Weight of second column (Age): 0.9

```python
def weighted_euclidean_distance(point1, point2):
    # point 1 is data.
    # point 2 is centroid

    # 0.1 for first feature and 0.9 for second feature
    weights_list = [0.1, 0.9]
    distance = 0.0

    if len(point1) == 2:  # when calculating the distance of two coordinates
        for i in range(len(point1)):
            distance += weights_list[i] * (point1[i] - point2[i]) ** 2.0
```

```
    else:  # when updating Centroid
        for i in range(len(point1)):
            distance += (point1[i] - point2[i]) ** 2.0

    return distance ** 0.5
```

❑ **Console window results**

```
Total number of People: 100
ID  Age Covid Status Severity Address
1   72  Contacted    0.125    충청남도
2   50  Healthy      0.0      경기도
3   49  Contacted    0.2      경상북도
4   45  Contacted    0.225    전라남도
5   45  Contacted    0.325    전라남도
6   66  Confirmed    0.55     부산광역시
7   86  Healthy      0.0      전라남도
8   43  Healthy      0.0      서울특별시
9   63  Healthy      0.0      경기도
10  81  Confirmed    0.35     광주광역시
11  2   Contacted    0.175    경상북도
12  69  Healthy      0.0      전라북도
13  66  Healthy      0.0      전라북도
14  37  Contacted    0.425    울산광역시
15  97  Healthy      0.0      경상북도
16  98  Healthy      0.0      경상북도
17  56  Confirmed    0.65     전라북도
18  26  Contacted    0.3      경상남도
19  90  Confirmed    0.9      전라북도
20  21  Confirmed    0.5      전라북도
21  26  Healthy      0.0      경상북도
22  17  Confirmed    0.45     제주특별자치도
23  55  Healthy      0.0      부산광역시
24  74  Healthy      0.0      경상북도
25  91  Contacted    0.275    경상북도
26  33  Healthy      0.0      대전광역시
27  1   Healthy      0.0      강원도
28  91  Confirmed    0.9      전라남도
29  74  Confirmed    0.45     전라남도
30  52  Contacted    0.275    경기도
31  49  Confirmed    0.4      전라남도
32  49  Confirmed    0.3      전라남도
33  13  Contacted    0.375    경상남도
34  90  Contacted    0.175    충청북도
35  40  Healthy      0.0      경상남도
36  59  Confirmed    0.9      인천광역시
37  21  Contacted    0.3      경상남도
```

38	99	Confirmed	0.3	경상남도
39	20	Healthy	0.0	경기도
40	21	Confirmed	0.95	전라북도
41	76	Healthy	0.0	제주특별자치도
42	17	Contacted	0.125	서울특별시
43	10	Healthy	0.0	전라북도
44	50	Contacted	0.45	인천광역시
45	58	Contacted	0.175	서울특별시
46	44	Confirmed	0.6	경상남도
47	1	Confirmed	0.75	강원도
48	94	Healthy	0.0	강원도
49	96	Healthy	0.0	울산광역시
50	96	Healthy	0.0	대전광역시
51	25	Healthy	0.0	전라북도
52	68	Contacted	0.375	강원도
53	59	Confirmed	0.3	경상북도
54	50	Confirmed	0.9	전라북도
55	13	Contacted	0.225	경상북도
56	76	Contacted	0.45	광주광역시
57	48	Contacted	0.3	부산광역시
58	53	Healthy	0.0	전라북도
59	12	Confirmed	0.85	서울특별시
60	43	Contacted	0.125	경상북도
61	54	Contacted	0.275	울산광역시
62	52	Confirmed	0.45	제주특별자치도
63	31	Confirmed	0.7	제주특별자치도
64	28	Contacted	0.275	전라남도
65	40	Contacted	0.2	경상남도
66	88	Confirmed	0.5	경기도
67	27	Contacted	0.275	충청남도
68	40	Confirmed	0.45	전라북도
69	66	Contacted	0.225	서울특별시
70	49	Contacted	0.375	충청남도
71	82	Healthy	0.0	광주광역시
72	7	Healthy	0.0	전라남도
73	78	Healthy	0.0	서울특별시
74	30	Contacted	0.325	서울특별시
75	87	Contacted	0.325	전라남도
76	72	Contacted	0.375	경상북도
77	67	Confirmed	0.35	서울특별시
78	16	Healthy	0.0	경기도
79	62	Contacted	0.45	전라북도
80	24	Healthy	0.0	경상북도
81	10	Confirmed	0.55	대구광역시

```
82  72  Confirmed    0.85     인천광역시
83  70  Contacted    0.2      경기도
84  30  Confirmed    0.6      경기도
85  37  Healthy      0.0      경상북도
86  23  Contacted    0.15     전라북도
87  13  Confirmed    0.55     경상남도
88  34  Confirmed    0.25     대구광역시
89  19  Confirmed    0.25     충청북도
90  12  Healthy      0.0      전라남도
91  88  Healthy      0.0      대구광역시
92  80  Healthy      0.0      충청북도
93  13  Healthy      0.0      서울특별시
94  46  Confirmed    0.65     서울특별시
95  49  Contacted    0.325    서울특별시
96  15  Confirmed    0.25     경기도
97  37  Confirmed    0.65     경기도
98  40  Healthy      0.0      경상남도
99  65  Confirmed    0.55     충청북도
100 45  Confirmed    0.65     충청남도

Number of healthy people: 33
Number of contacted people: 33
Number of confirmed people: 34
Average Severity of contacted people: 0.28
Average Severity of confirmed people: 0.57

Number of Clusters: 2
    Cluster 0:
        Number of People: 47
        Average of Age: 25.38
        Average of severities: 0.29
        The Coordinates of Centroid:
            X1 (Severity): 0.3
            X2 (Age): 0.25

    Cluster 1:
        Number of People: 53
        Average of Age: 70.4
        Average of severities: 0.28
        The Coordinates of Centroid:
            X1 (Severity): 0.3
            X2 (Age): 0.71

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          47 |         25.38 |             0.29
              1 |          53 |          70.4 |             0.28
```

```
    ------------|-------------|---------------|------------------
       Total    |         100 |
        SSE     |       15.31 |
    ------------------------------------------------------------

Number of Clusters: 3
    Cluster 0:
        Number of People: 31
        Average of Age: 17.55
        Average of severities: 0.29
        The Coordinates of Centroid:
            X1 (Severity): 0.3
            X2 (Age): 0.17

    Cluster 1:
        Number of People: 35
        Average of Age: 47.2
        Average of severities: 0.32
        The Coordinates of Centroid:
            X1 (Severity): 0.34
            X2 (Age): 0.47

    Cluster 2:
        Number of People: 34
        Average of Age: 80.24
        Average of severities: 0.24
        The Coordinates of Centroid:
            X1 (Severity): 0.25
            X2 (Age): 0.81

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          31 |         17.55 |           0.29
              1 |          35 |          47.2 |           0.32
              2 |          34 |         80.24 |           0.24
    ------------|-------------|---------------|------------------
       Total    |         100 |
        SSE     |       11.28 |
    ------------------------------------------------------------

Number of Clusters: 4
    Cluster 0:
        Number of People: 17
        Average of Age: 16.24
        Average of severities: 0.07
        The Coordinates of Centroid:
            X1 (Severity): 0.07
            X2 (Age): 0.16
```

```
    Cluster 1:
        Number of People: 15
        Average of Age: 20.07
        Average of severities: 0.52
        The Coordinates of Centroid:
            X1 (Severity): 0.54
            X2 (Age): 0.19

    Cluster 2:
        Number of People: 34
        Average of Age: 47.62
        Average of severities: 0.33
        The Coordinates of Centroid:
            X1 (Severity): 0.35
            X2 (Age): 0.48

    Cluster 3:
        Number of People: 34
        Average of Age: 80.24
        Average of severities: 0.24
        The Coordinates of Centroid:
            X1 (Severity): 0.25
            X2 (Age): 0.81

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          17 |         16.24 |             0.07
              1 |          15 |         20.07 |             0.52
              2 |          34 |         47.62 |             0.33
              3 |          34 |         80.24 |             0.24
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |       10.49 |
    ------------------------------------------------------------

Number of Clusters: 5
    Cluster 0:
        Number of People: 17
        Average of Age: 15.53
        Average of severities: 0.09
        The Coordinates of Centroid:
            X1 (Severity): 0.09
            X2 (Age): 0.15

    Cluster 1:
        Number of People: 8
        Average of Age: 13.5
        Average of severities: 0.62
        The Coordinates of Centroid:
```

```
            X1 (Severity): 0.65
            X2 (Age): 0.13

    Cluster 2:
        Number of People: 20
        Average of Age: 36.5
        Average of severities: 0.29
        The Coordinates of Centroid:
            X1 (Severity): 0.3
            X2 (Age): 0.36

    Cluster 3:
        Number of People: 29
        Average of Age: 56.1
        Average of severities: 0.38
        The Coordinates of Centroid:
            X1 (Severity): 0.4
            X2 (Age): 0.56

    Cluster 4:
        Number of People: 26
        Average of Age: 84.42
        Average of severities: 0.2
        The Coordinates of Centroid:
            X1 (Severity): 0.22
            X2 (Age): 0.85

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          17 |         15.53 |           0.09
              1 |           8 |          13.5 |           0.62
              2 |          20 |          36.5 |           0.29
              3 |          29 |          56.1 |           0.38
              4 |          26 |         84.42 |            0.2
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |        9.73 |
    ------------------------------------------------------------

Number of Clusters: 6
    Cluster 0:
        Number of People: 13
        Average of Age: 12.77
        Average of severities: 0.1
        The Coordinates of Centroid:
            X1 (Severity): 0.11
            X2 (Age): 0.12

    Cluster 1:
```

```
        Number of People: 8
        Average of Age: 13.5
        Average of severities: 0.62
        The Coordinates of Centroid:
            X1 (Severity): 0.65
            X2 (Age): 0.13

    Cluster 2:
        Number of People: 16
        Average of Age: 32.44
        Average of severities: 0.12
        The Coordinates of Centroid:
            X1 (Severity): 0.12
            X2 (Age): 0.32

    Cluster 3:
        Number of People: 9
        Average of Age: 40.0
        Average of severities: 0.62
        The Coordinates of Centroid:
            X1 (Severity): 0.66
            X2 (Age): 0.4

    Cluster 4:
        Number of People: 27
        Average of Age: 55.7
        Average of severities: 0.31
        The Coordinates of Centroid:
            X1 (Severity): 0.33
            X2 (Age): 0.56

    Cluster 5:
        Number of People: 27
        Average of Age: 83.96
        Average of severities: 0.23
        The Coordinates of Centroid:
            X1 (Severity): 0.24
            X2 (Age): 0.85

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          13 |         12.77 |            0.1
              1 |           8 |          13.5 |           0.62
              2 |          16 |         32.44 |           0.12
              3 |           9 |          40.0 |           0.62
              4 |          27 |          55.7 |           0.31
              5 |          27 |         83.96 |           0.23
    ------------|-------------|---------------|-----------------
       Total    |         100 |
```

```
        SSE     |        9.12 |
    ------------------------------------------------------------

Number of Clusters: 7
    Cluster 0:
        Number of People: 10
        Average of Age: 10.6
        Average of severities: 0.08
        The Coordinates of Centroid:
            X1 (Severity): 0.08
            X2 (Age): 0.1

    Cluster 1:
        Number of People: 8
        Average of Age: 13.5
        Average of severities: 0.62
        The Coordinates of Centroid:
            X1 (Severity): 0.65
            X2 (Age): 0.13

    Cluster 2:
        Number of People: 13
        Average of Age: 25.85
        Average of severities: 0.16
        The Coordinates of Centroid:
            X1 (Severity): 0.17
            X2 (Age): 0.25

    Cluster 3:
        Number of People: 9
        Average of Age: 40.0
        Average of severities: 0.62
        The Coordinates of Centroid:
            X1 (Severity): 0.66
            X2 (Age): 0.4

    Cluster 4:
        Number of People: 21
        Average of Age: 47.24
        Average of severities: 0.2
        The Coordinates of Centroid:
            X1 (Severity): 0.21
            X2 (Age): 0.47

    Cluster 5:
        Number of People: 20
        Average of Age: 66.7
        Average of severities: 0.35
        The Coordinates of Centroid:
```

```
            X1 (Severity): 0.37
            X2 (Age): 0.67

    Cluster 6:
        Number of People: 19
        Average of Age: 88.84
        Average of severities: 0.2
        The Coordinates of Centroid:
            X1 (Severity): 0.21
            X2 (Age): 0.9

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          10 |          10.6 |           0.08
              1 |           8 |          13.5 |           0.62
              2 |          13 |         25.85 |           0.16
              3 |           9 |          40.0 |           0.62
              4 |          21 |         47.24 |            0.2
              5 |          20 |          66.7 |           0.35
              6 |          19 |         88.84 |            0.2
    ------------|-------------|---------------|------------------
       Total    |         100 |
        SSE     |        7.78 |
    ------------------------------------------------------------

Number of Clusters: 8
    Cluster 0:
        Number of People: 7
        Average of Age: 8.29
        Average of severities: 0.06
        The Coordinates of Centroid:
            X1 (Severity): 0.06
            X2 (Age): 0.07

    Cluster 1:
        Number of People: 8
        Average of Age: 13.5
        Average of severities: 0.62
        The Coordinates of Centroid:
            X1 (Severity): 0.65
            X2 (Age): 0.13

    Cluster 2:
        Number of People: 13
        Average of Age: 22.08
        Average of severities: 0.15
        The Coordinates of Centroid:
            X1 (Severity): 0.16
            X2 (Age): 0.22
```

```
Cluster 3:
    Number of People: 7
    Average of Age: 34.14
    Average of severities: 0.49
    The Coordinates of Centroid:
        X1 (Severity): 0.51
        X2 (Age): 0.34

Cluster 4:
    Number of People: 12
    Average of Age: 44.0
    Average of severities: 0.06
    The Coordinates of Centroid:
        X1 (Severity): 0.07
        X2 (Age): 0.44

Cluster 5:
    Number of People: 16
    Average of Age: 49.81
    Average of severities: 0.49
    The Coordinates of Centroid:
        X1 (Severity): 0.51
        X2 (Age): 0.5

Cluster 6:
    Number of People: 19
    Average of Age: 68.16
    Average of severities: 0.29
    The Coordinates of Centroid:
        X1 (Severity): 0.3
        X2 (Age): 0.69

Cluster 7:
    Number of People: 18
    Average of Age: 89.56
    Average of severities: 0.21
    The Coordinates of Centroid:
        X1 (Severity): 0.22
        X2 (Age): 0.9

-------------------------------------------------------------
 Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
          0 |           7 |          8.29 |           0.06
          1 |           8 |          13.5 |           0.62
          2 |          13 |         22.08 |           0.15
          3 |           7 |         34.14 |           0.49
          4 |          12 |          44.0 |           0.06
          5 |          16 |         49.81 |           0.49
```

```
            6 |          19 |         68.16 |           0.29
            7 |          18 |         89.56 |           0.21
    ------------|-------------|---------------|------------------
       Total    |         100 |
        SSE     |         7.4 |
    ------------------------------------------------------------

Number of Clusters: 9
    Cluster 0:
        Number of People: 7
        Average of Age: 8.29
        Average of severities: 0.06
        The Coordinates of Centroid:
            X1 (Severity): 0.06
            X2 (Age): 0.07

    Cluster 1:
        Number of People: 8
        Average of Age: 13.5
        Average of severities: 0.62
        The Coordinates of Centroid:
            X1 (Severity): 0.65
            X2 (Age): 0.13

    Cluster 2:
        Number of People: 13
        Average of Age: 22.08
        Average of severities: 0.15
        The Coordinates of Centroid:
            X1 (Severity): 0.16
            X2 (Age): 0.22

    Cluster 3:
        Number of People: 7
        Average of Age: 34.14
        Average of severities: 0.49
        The Coordinates of Centroid:
            X1 (Severity): 0.51
            X2 (Age): 0.34

    Cluster 4:
        Number of People: 12
        Average of Age: 44.0
        Average of severities: 0.06
        The Coordinates of Centroid:
            X1 (Severity): 0.07
            X2 (Age): 0.44

    Cluster 5:
```

```
        Number of People: 15
        Average of Age: 49.2
        Average of severities: 0.46
        The Coordinates of Centroid:
            X1 (Severity): 0.49
            X2 (Age): 0.49

    Cluster 6:
        Number of People: 13
        Average of Age: 66.46
        Average of severities: 0.46
        The Coordinates of Centroid:
            X1 (Severity): 0.49
            X2 (Age): 0.67

    Cluster 7:
        Number of People: 10
        Average of Age: 73.0
        Average of severities: 0.03
        The Coordinates of Centroid:
            X1 (Severity): 0.03
            X2 (Age): 0.73

    Cluster 8:
        Number of People: 15
        Average of Age: 91.47
        Average of severities: 0.25
        The Coordinates of Centroid:
            X1 (Severity): 0.26
            X2 (Age): 0.92

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |           7 |          8.29 |           0.06
              1 |           8 |          13.5 |           0.62
              2 |          13 |         22.08 |           0.15
              3 |           7 |         34.14 |           0.49
              4 |          12 |          44.0 |           0.06
              5 |          15 |          49.2 |           0.46
              6 |          13 |         66.46 |           0.46
              7 |          10 |          73.0 |           0.03
              8 |          15 |         91.47 |           0.25
    ------------|-------------|---------------|------------------
       Total    |         100 |
        SSE     |        6.82 |
    ------------------------------------------------------------


Process finished with exit code 0
```

3.2.3. K-means Algorithm using Euclidean Distance Function

- **Used Columns: Age, Severity**
- **Distance Function: Euclidean Distance**

  The Euclidean distance between points p and q is the length of the line segment connecting (pq)

  - Euclidean Formula

$$d(\mathbf{p},\mathbf{q}) = d(\mathbf{q},\mathbf{p}) = \sqrt{(q_1 - p_1)^2 + (q_2 - p_2)^2 + \cdots + (q_n - p_n)^2}$$

$$= \sqrt{\sum_{i=1}^{n} (q_i - p_i)^2}.$$

- **Console window results**

```
Total number of People: 100
ID  Age Covid Status Severity Address
1   72  Contacted    0.125    충청남도
2   50  Healthy      0.0      경기도
3   49  Contacted    0.2      경상북도
4   45  Contacted    0.225    전라남도
5   45  Contacted    0.325    전라남도
6   66  Confirmed    0.55     부산광역시
7   86  Healthy      0.0      전라남도
8   43  Healthy      0.0      서울특별시
9   63  Healthy      0.0      경기도
10  81  Confirmed    0.35     광주광역시
11  2   Contacted    0.175    경상북도
12  69  Healthy      0.0      전라북도
13  66  Healthy      0.0      전라북도
14  37  Contacted    0.425    울산광역시
15  97  Healthy      0.0      경상북도
16  98  Healthy      0.0      경상북도
17  56  Confirmed    0.65     전라북도
18  26  Contacted    0.3      경상남도
19  90  Confirmed    0.9      전라북도
20  21  Confirmed    0.5      전라북도
21  26  Healthy      0.0      경상북도
22  17  Confirmed    0.45     제주특별자치도
23  55  Healthy      0.0      부산광역시
24  74  Healthy      0.0      경상북도
25  91  Contacted    0.275    경상북도
26  33  Healthy      0.0      대전광역시
27  1   Healthy      0.0      강원도
28  91  Confirmed    0.9      전라남도
```

29	74	Confirmed	0.45	전라남도
30	52	Contacted	0.275	경기도
31	49	Confirmed	0.4	전라남도
32	49	Confirmed	0.3	전라남도
33	13	Contacted	0.375	경상남도
34	90	Contacted	0.175	충청북도
35	40	Healthy	0.0	경상남도
36	59	Confirmed	0.9	인천광역시
37	21	Contacted	0.3	경상남도
38	99	Confirmed	0.3	경상남도
39	20	Healthy	0.0	경기도
40	21	Confirmed	0.95	전라북도
41	76	Healthy	0.0	제주특별자치도
42	17	Contacted	0.125	서울특별시
43	10	Healthy	0.0	전라북도
44	50	Contacted	0.45	인천광역시
45	58	Contacted	0.175	서울특별시
46	44	Confirmed	0.6	경상남도
47	1	Confirmed	0.75	강원도
48	94	Healthy	0.0	강원도
49	96	Healthy	0.0	울산광역시
50	96	Healthy	0.0	대전광역시
51	25	Healthy	0.0	전라북도
52	68	Contacted	0.375	강원도
53	59	Confirmed	0.3	경상북도
54	50	Confirmed	0.9	전라북도
55	13	Contacted	0.225	경상북도
56	76	Contacted	0.45	광주광역시
57	48	Contacted	0.3	부산광역시
58	53	Healthy	0.0	전라북도
59	12	Confirmed	0.85	서울특별시
60	43	Contacted	0.125	경상북도
61	54	Contacted	0.275	울산광역시
62	52	Confirmed	0.45	제주특별자치도
63	31	Confirmed	0.7	제주특별자치도
64	28	Contacted	0.275	전라남도
65	40	Contacted	0.2	경상남도
66	88	Confirmed	0.5	경기도
67	27	Contacted	0.275	충청남도
68	40	Confirmed	0.45	전라북도
69	66	Contacted	0.225	서울특별시
70	49	Contacted	0.375	충청남도
71	82	Healthy	0.0	광주광역시
72	7	Healthy	0.0	전라남도

```
73  78  Healthy     0.0      서울특별시
74  30  Contacted   0.325    서울특별시
75  87  Contacted   0.325    전라남도
76  72  Contacted   0.375    경상북도
77  67  Confirmed   0.35     서울특별시
78  16  Healthy     0.0      경기도
79  62  Contacted   0.45     전라북도
80  24  Healthy     0.0      경상북도
81  10  Confirmed   0.55     대구광역시
82  72  Confirmed   0.85     인천광역시
83  70  Contacted   0.2      경기도
84  30  Confirmed   0.6      경기도
85  37  Healthy     0.0      경상북도
86  23  Contacted   0.15     전라북도
87  13  Confirmed   0.55     경상남도
88  34  Confirmed   0.25     대구광역시
89  19  Confirmed   0.25     충청북도
90  12  Healthy     0.0      전라남도
91  88  Healthy     0.0      대구광역시
92  80  Healthy     0.0      충청북도
93  13  Healthy     0.0      서울특별시
94  46  Confirmed   0.65     서울특별시
95  49  Contacted   0.325    서울특별시
96  15  Confirmed   0.25     경기도
97  37  Confirmed   0.65     경기도
98  40  Healthy     0.0      경상남도
99  65  Confirmed   0.55     충청북도
100 45  Confirmed   0.65     충청남도

Number of healthy people: 33
Number of contacted people: 33
Number of confirmed people: 34
Average Severity of contacted people: 0.28
Average Severity of confirmed people: 0.57

Number of Clusters: 2
    Cluster 0:
        Number of People: 69
        Average of Age: 50.81
        Average of severities: 0.14
        The Coordinates of Centroid:
            X1 (Severity): 0.14
            X2 (Age): 0.51

    Cluster 1:
        Number of People: 31
```

```
        Average of Age: 45.74
        Average of severities: 0.61
        The Coordinates of Centroid:
            X1 (Severity): 0.65
            X2 (Age): 0.46

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          69 |         50.81 |           0.14
              1 |          31 |         45.74 |           0.61
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |       28.95 |
    ------------------------------------------------------------

Number of Clusters: 3
    Cluster 0:
        Number of People: 38
        Average of Age: 27.63
        Average of severities: 0.15
        The Coordinates of Centroid:
            X1 (Severity): 0.16
            X2 (Age): 0.27

    Cluster 1:
        Number of People: 35
        Average of Age: 76.43
        Average of severities: 0.16
        The Coordinates of Centroid:
            X1 (Severity): 0.17
            X2 (Age): 0.77

    Cluster 2:
        Number of People: 27
        Average of Age: 44.41
        Average of severities: 0.64
        The Coordinates of Centroid:
            X1 (Severity): 0.67
            X2 (Age): 0.44

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          38 |         27.63 |           0.15
              1 |          35 |         76.43 |           0.16
              2 |          27 |         44.41 |           0.64
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |        22.2 |
    ------------------------------------------------------------
```

```
Number of Clusters: 4
    Cluster 0:
        Number of People: 22
        Average of Age: 23.18
        Average of severities: 0.05
        The Coordinates of Centroid:
            X1 (Severity): 0.05
            X2 (Age): 0.23

    Cluster 1:
        Number of People: 17
        Average of Age: 48.0
        Average of severities: 0.74
        The Coordinates of Centroid:
            X1 (Severity): 0.78
            X2 (Age): 0.48

    Cluster 2:
        Number of People: 32
        Average of Age: 78.44
        Average of severities: 0.15
        The Coordinates of Centroid:
            X1 (Severity): 0.15
            X2 (Age): 0.79

    Cluster 3:
        Number of People: 29
        Average of Age: 37.52
        Average of severities: 0.35
        The Coordinates of Centroid:
            X1 (Severity): 0.37
            X2 (Age): 0.37

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          22 |         23.18 |           0.05
              1 |          17 |          48.0 |           0.74
              2 |          32 |         78.44 |           0.15
              3 |          29 |         37.52 |           0.35
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |       19.48 |
    ------------------------------------------------------------

Number of Clusters: 5
    Cluster 0:
        Number of People: 31
        Average of Age: 24.13
```

```
        Average of severities: 0.12
        The Coordinates of Centroid:
            X1 (Severity): 0.12
            X2 (Age): 0.24

    Cluster 1:
        Number of People: 21
        Average of Age: 81.1
        Average of severities: 0.04
        The Coordinates of Centroid:
            X1 (Severity): 0.04
            X2 (Age): 0.82

    Cluster 2:
        Number of People: 5
        Average of Age: 72.4
        Average of severities: 0.89
        The Coordinates of Centroid:
            X1 (Severity): 0.94
            X2 (Age): 0.73

    Cluster 3:
        Number of People: 16
        Average of Age: 28.81
        Average of severities: 0.62
        The Coordinates of Centroid:
            X1 (Severity): 0.66
            X2 (Age): 0.28

    Cluster 4:
        Number of People: 27
        Average of Age: 61.11
        Average of severities: 0.35
        The Coordinates of Centroid:
            X1 (Severity): 0.37
            X2 (Age): 0.61

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          31 |         24.13 |           0.12
              1 |          21 |          81.1 |           0.04
              2 |           5 |          72.4 |           0.89
              3 |          16 |         28.81 |           0.62
              4 |          27 |         61.11 |           0.35
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |       16.89 |
    ------------------------------------------------------------
```

```
Number of Clusters: 6
    Cluster 0:
        Number of People: 26
        Average of Age: 57.12
        Average of severities: 0.35
        The Coordinates of Centroid:
            X1 (Severity): 0.37
            X2 (Age): 0.57

    Cluster 1:
        Number of People: 5
        Average of Age: 80.0
        Average of severities: 0.81
        The Coordinates of Centroid:
            X1 (Severity): 0.85
            X2 (Age): 0.81

    Cluster 2:
        Number of People: 23
        Average of Age: 80.87
        Average of severities: 0.06
        The Coordinates of Centroid:
            X1 (Severity): 0.06
            X2 (Age): 0.81

    Cluster 3:
        Number of People: 11
        Average of Age: 33.91
        Average of severities: 0.72
        The Coordinates of Centroid:
            X1 (Severity): 0.76
            X2 (Age): 0.34

    Cluster 4:
        Number of People: 20
        Average of Age: 24.1
        Average of severities: 0.03
        The Coordinates of Centroid:
            X1 (Severity): 0.03
            X2 (Age): 0.24

    Cluster 5:
        Number of People: 15
        Average of Age: 21.6
        Average of severities: 0.35
        The Coordinates of Centroid:
            X1 (Severity): 0.37
            X2 (Age): 0.21
```

```
    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          26 |         57.12 |           0.35
              1 |           5 |          80.0 |           0.81
              2 |          23 |         80.87 |           0.06
              3 |          11 |         33.91 |           0.72
              4 |          20 |          24.1 |           0.03
              5 |          15 |          21.6 |           0.35
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |       15.39 |
    ------------------------------------------------------------

Number of Clusters: 7
    Cluster 0:
        Number of People: 16
        Average of Age: 15.19
        Average of severities: 0.07
        The Coordinates of Centroid:
            X1 (Severity): 0.08
            X2 (Age): 0.14

    Cluster 1:
        Number of People: 11
        Average of Age: 18.73
        Average of severities: 0.63
        The Coordinates of Centroid:
            X1 (Severity): 0.66
            X2 (Age): 0.18

    Cluster 2:
        Number of People: 13
        Average of Age: 77.0
        Average of severities: 0.36
        The Coordinates of Centroid:
            X1 (Severity): 0.37
            X2 (Age): 0.78

    Cluster 3:
        Number of People: 11
        Average of Age: 62.18
        Average of severities: 0.74
        The Coordinates of Centroid:
            X1 (Severity): 0.78
            X2 (Age): 0.62

    Cluster 4:
        Number of People: 12
        Average of Age: 48.42
```

```
        Average of severities: 0.02
        The Coordinates of Centroid:
            X1 (Severity): 0.03
            X2 (Age): 0.48

    Cluster 5:
        Number of People: 22
        Average of Age: 42.41
        Average of severities: 0.32
        The Coordinates of Centroid:
            X1 (Severity): 0.33
            X2 (Age): 0.42

    Cluster 6:
        Number of People: 15
        Average of Age: 85.07
        Average of severities: 0.02
        The Coordinates of Centroid:
            X1 (Severity): 0.02
            X2 (Age): 0.86

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          16 |         15.19 |             0.07
              1 |          11 |         18.73 |             0.63
              2 |          13 |          77.0 |             0.36
              3 |          11 |         62.18 |             0.74
              4 |          12 |         48.42 |             0.02
              5 |          22 |         42.41 |             0.32
              6 |          15 |         85.07 |             0.02
    ------------|-------------|---------------|------------------
       Total    |         100 |
        SSE     |        13.7 |
    ------------------------------------------------------------

Number of Clusters: 8
    Cluster 0:
        Number of People: 23
        Average of Age: 19.22
        Average of severities: 0.13
        The Coordinates of Centroid:
            X1 (Severity): 0.13
            X2 (Age): 0.19

    Cluster 1:
        Number of People: 9
        Average of Age: 15.33
        Average of severities: 0.62
        The Coordinates of Centroid:
```

```
            X1 (Severity): 0.65
            X2 (Age): 0.15

    Cluster 2:
        Number of People: 3
        Average of Age: 84.33
        Average of severities: 0.88
        The Coordinates of Centroid:
            X1 (Severity): 0.93
            X2 (Age): 0.85

    Cluster 3:
        Number of People: 19
        Average of Age: 52.95
        Average of severities: 0.38
        The Coordinates of Centroid:
            X1 (Severity): 0.4
            X2 (Age): 0.53

    Cluster 4:
        Number of People: 13
        Average of Age: 87.31
        Average of severities: 0.01
        The Coordinates of Centroid:
            X1 (Severity): 0.01
            X2 (Age): 0.88

    Cluster 5:
        Number of People: 8
        Average of Age: 83.5
        Average of severities: 0.38
        The Coordinates of Centroid:
            X1 (Severity): 0.4
            X2 (Age): 0.84

    Cluster 6:
        Number of People: 8
        Average of Age: 46.0
        Average of severities: 0.71
        The Coordinates of Centroid:
            X1 (Severity): 0.75
            X2 (Age): 0.46

    Cluster 7:
        Number of People: 17
        Average of Age: 53.76
        Average of severities: 0.07
        The Coordinates of Centroid:
            X1 (Severity): 0.08
```

```
            X2 (Age): 0.54

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          23 |         19.22 |           0.13
              1 |           9 |         15.33 |           0.62
              2 |           3 |         84.33 |           0.88
              3 |          19 |         52.95 |           0.38
              4 |          13 |         87.31 |           0.01
              5 |           8 |          83.5 |           0.38
              6 |           8 |          46.0 |           0.71
              7 |          17 |         53.76 |           0.07
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |       13.46 |
    ------------------------------------------------------------

Number of Clusters: 9
    Cluster 0:
        Number of People: 17
        Average of Age: 82.65
        Average of severities: 0.02
        The Coordinates of Centroid:
            X1 (Severity): 0.02
            X2 (Age): 0.83

    Cluster 1:
        Number of People: 8
        Average of Age: 17.38
        Average of severities: 0.68
        The Coordinates of Centroid:
            X1 (Severity): 0.72
            X2 (Age): 0.17

    Cluster 2:
        Number of People: 2
        Average of Age: 90.5
        Average of severities: 0.9
        The Coordinates of Centroid:
            X1 (Severity): 0.95
            X2 (Age): 0.91

    Cluster 3:
        Number of People: 14
        Average of Age: 20.36
        Average of severities: 0.27
        The Coordinates of Centroid:
            X1 (Severity): 0.28
            X2 (Age): 0.2
```

```
Cluster 4:
    Number of People: 11
    Average of Age: 79.36
    Average of severities: 0.36
    The Coordinates of Centroid:
        X1 (Severity): 0.38
        X2 (Age): 0.8

Cluster 5:
    Number of People: 15
    Average of Age: 50.33
    Average of severities: 0.27
    The Coordinates of Centroid:
        X1 (Severity): 0.28
        X2 (Age): 0.5

Cluster 6:
    Number of People: 3
    Average of Age: 60.33
    Average of severities: 0.88
    The Coordinates of Centroid:
        X1 (Severity): 0.93
        X2 (Age): 0.61

Cluster 7:
    Number of People: 18
    Average of Age: 28.06
    Average of severities: 0.0
    The Coordinates of Centroid:
        X1 (Severity): 0.0
        X2 (Age): 0.28

Cluster 8:
    Number of People: 12
    Average of Age: 50.0
    Average of severities: 0.54
    The Coordinates of Centroid:
        X1 (Severity): 0.57
        X2 (Age): 0.5

-------------------------------------------------------------
 Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
          0 |          17 |         82.65 |           0.02
          1 |           8 |         17.38 |           0.68
          2 |           2 |          90.5 |            0.9
          3 |          14 |         20.36 |           0.27
          4 |          11 |         79.36 |           0.36
          5 |          15 |         50.33 |           0.27
```

```
           6 |           3 |         60.33 |           0.88
           7 |          18 |         28.06 |            0.0
           8 |          12 |          50.0 |           0.54
-------------|-------------|---------------|-----------------
   Total     |         100 |
    SSE      |       12.04 |
-------------------------------------------------------------
```

3.2.4. K-means Algorithm using Manhattan Distance Function

- **Used Columns: Age, Severity**
- **Distance Function: Manhattan Distance**

  The taxicab distance, in an n-dimensional real vector space with fixed Cartesian coordinate system, is the sum of the lengths of the projections of the line segment between the points onto the coordinate axes.

  - Function of Manhattan Distance Formula

$$d_1(\mathbf{p}, \mathbf{q}) = \|\mathbf{p} - \mathbf{q}\|_1 = \sum_{i=1}^{n} |p_i - q_i|,$$

where (p, q) are vectors

d_1 is Manhattan distance, and

$$\mathbf{p} = (p_1, p_2, \ldots, p_n)$$

and

$$\mathbf{q} = (q_1, q_2, \ldots, q_n)$$

- **Console window results**

```
Total number of People: 100
ID  Age Covid Status Severity Address
1   72  Contacted    0.125    충청남도
2   50  Healthy      0.0      경기도
3   49  Contacted    0.2      경상북도
4   45  Contacted    0.225    전라남도
5   45  Contacted    0.325    전라남도
6   66  Confirmed    0.55     부산광역시
7   86  Healthy      0.0      전라남도
8   43  Healthy      0.0      서울특별시
9   63  Healthy      0.0      경기도
10  81  Confirmed    0.35     광주광역시
11  2   Contacted    0.175    경상북도
```

12	69	Healthy	0.0	전라북도
13	66	Healthy	0.0	전라북도
14	37	Contacted	0.425	울산광역시
15	97	Healthy	0.0	경상북도
16	98	Healthy	0.0	경상북도
17	56	Confirmed	0.65	전라북도
18	26	Contacted	0.3	경상남도
19	90	Confirmed	0.9	전라북도
20	21	Confirmed	0.5	전라북도
21	26	Healthy	0.0	경상북도
22	17	Confirmed	0.45	제주특별자치도
23	55	Healthy	0.0	부산광역시
24	74	Healthy	0.0	경상북도
25	91	Contacted	0.275	경상북도
26	33	Healthy	0.0	대전광역시
27	1	Healthy	0.0	강원도
28	91	Confirmed	0.9	전라남도
29	74	Confirmed	0.45	전라남도
30	52	Contacted	0.275	경기도
31	49	Confirmed	0.4	전라남도
32	49	Confirmed	0.3	전라남도
33	13	Contacted	0.375	경상남도
34	90	Contacted	0.175	충청북도
35	40	Healthy	0.0	경상남도
36	59	Confirmed	0.9	인천광역시
37	21	Contacted	0.3	경상남도
38	99	Confirmed	0.3	경상남도
39	20	Healthy	0.0	경기도
40	21	Confirmed	0.95	전라북도
41	76	Healthy	0.0	제주특별자치도
42	17	Contacted	0.125	서울특별시
43	10	Healthy	0.0	전라북도
44	50	Contacted	0.45	인천광역시
45	58	Contacted	0.175	서울특별시
46	44	Confirmed	0.6	경상남도
47	1	Confirmed	0.75	강원도
48	94	Healthy	0.0	강원도
49	96	Healthy	0.0	울산광역시
50	96	Healthy	0.0	대전광역시
51	25	Healthy	0.0	전라북도
52	68	Contacted	0.375	강원도
53	59	Confirmed	0.3	경상북도
54	50	Confirmed	0.9	전라북도
55	13	Contacted	0.225	경상북도

56	76	Contacted	0.45	광주광역시
57	48	Contacted	0.3	부산광역시
58	53	Healthy	0.0	전라북도
59	12	Confirmed	0.85	서울특별시
60	43	Contacted	0.125	경상북도
61	54	Contacted	0.275	울산광역시
62	52	Confirmed	0.45	제주특별자치도
63	31	Confirmed	0.7	제주특별자치도
64	28	Contacted	0.275	전라남도
65	40	Contacted	0.2	경상남도
66	88	Confirmed	0.5	경기도
67	27	Contacted	0.275	충청남도
68	40	Confirmed	0.45	전라북도
69	66	Contacted	0.225	서울특별시
70	49	Contacted	0.375	충청남도
71	82	Healthy	0.0	광주광역시
72	7	Healthy	0.0	전라남도
73	78	Healthy	0.0	서울특별시
74	30	Contacted	0.325	서울특별시
75	87	Contacted	0.325	전라남도
76	72	Contacted	0.375	경상북도
77	67	Confirmed	0.35	서울특별시
78	16	Healthy	0.0	경기도
79	62	Contacted	0.45	전라북도
80	24	Healthy	0.0	경상북도
81	10	Confirmed	0.55	대구광역시
82	72	Confirmed	0.85	인천광역시
83	70	Contacted	0.2	경기도
84	30	Confirmed	0.6	경기도
85	37	Healthy	0.0	경상북도
86	23	Contacted	0.15	전라북도
87	13	Confirmed	0.55	경상남도
88	34	Confirmed	0.25	대구광역시
89	19	Confirmed	0.25	충청북도
90	12	Healthy	0.0	전라남도
91	88	Healthy	0.0	대구광역시
92	80	Healthy	0.0	충청북도
93	13	Healthy	0.0	서울특별시
94	46	Confirmed	0.65	서울특별시
95	49	Contacted	0.325	서울특별시
96	15	Confirmed	0.25	경기도
97	37	Confirmed	0.65	경기도
98	40	Healthy	0.0	경상남도
99	65	Confirmed	0.55	충청북도

```
100 45  Confirmed    0.65     충청남도

Number of healthy people: 33
Number of contacted people: 33
Number of confirmed people: 34
Average Severity of contacted people: 0.28
Average Severity of confirmed people: 0.57

Number of Clusters: 2
    Cluster 0:
        Number of People: 69
        Average of Age: 50.81
        Average of severities: 0.14
        The Coordinates of Centroid:
            X1 (Severity): 0.14
            X2 (Age): 0.51

    Cluster 1:
        Number of People: 31
        Average of Age: 45.74
        Average of severities: 0.61
        The Coordinates of Centroid:
            X1 (Severity): 0.65
            X2 (Age): 0.46

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          69 |         50.81 |             0.14
              1 |          31 |         45.74 |             0.61
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |       37.34 |
    ------------------------------------------------------------

Number of Clusters: 3
    Cluster 0:
        Number of People: 36
        Average of Age: 75.67
        Average of severities: 0.16
        The Coordinates of Centroid:
            X1 (Severity): 0.17
            X2 (Age): 0.76

    Cluster 1:
        Number of People: 33
        Average of Age: 24.55
        Average of severities: 0.13
        The Coordinates of Centroid:
            X1 (Severity): 0.14
```

```
            X2 (Age): 0.24

    Cluster 2:
        Number of People: 31
        Average of Age: 44.84
        Average of severities: 0.6
        The Coordinates of Centroid:
            X1 (Severity): 0.63
            X2 (Age): 0.45

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          36 |         75.67 |           0.16
              1 |          33 |         24.55 |           0.13
              2 |          31 |         44.84 |            0.6
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |       28.52 |
    ------------------------------------------------------------

Number of Clusters: 4
    Cluster 0:
        Number of People: 18
        Average of Age: 66.17
        Average of severities: 0.61
        The Coordinates of Centroid:
            X1 (Severity): 0.65
            X2 (Age): 0.66

    Cluster 1:
        Number of People: 24
        Average of Age: 24.25
        Average of severities: 0.05
        The Coordinates of Centroid:
            X1 (Severity): 0.06
            X2 (Age): 0.24

    Cluster 2:
        Number of People: 25
        Average of Age: 80.48
        Average of severities: 0.09
        The Coordinates of Centroid:
            X1 (Severity): 0.09
            X2 (Age): 0.81

    Cluster 3:
        Number of People: 33
        Average of Age: 34.52
        Average of severities: 0.42
```

```
        The Coordinates of Centroid:
            X1 (Severity): 0.44
            X2 (Age): 0.34

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          18 |         66.17 |             0.61
              1 |          24 |         24.25 |             0.05
              2 |          25 |         80.48 |             0.09
              3 |          33 |         34.52 |             0.42
    ------------|-------------|---------------|------------------
       Total    |         100 |
        SSE     |       25.43 |
    ------------------------------------------------------------

Number of Clusters: 5
    Cluster 0:
        Number of People: 20
        Average of Age: 78.15
        Average of severities: 0.01
        The Coordinates of Centroid:
            X1 (Severity): 0.02
            X2 (Age): 0.79

    Cluster 1:
        Number of People: 16
        Average of Age: 28.81
        Average of severities: 0.62
        The Coordinates of Centroid:
            X1 (Severity): 0.66
            X2 (Age): 0.28

    Cluster 2:
        Number of People: 30
        Average of Age: 23.27
        Average of severities: 0.12
        The Coordinates of Centroid:
            X1 (Severity): 0.13
            X2 (Age): 0.23

    Cluster 3:
        Number of People: 29
        Average of Age: 63.45
        Average of severities: 0.35
        The Coordinates of Centroid:
            X1 (Severity): 0.37
            X2 (Age): 0.64

    Cluster 4:
```

```
        Number of People: 5
        Average of Age: 72.4
        Average of severities: 0.89
        The Coordinates of Centroid:
            X1 (Severity): 0.94
            X2 (Age): 0.73

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          20 |         78.15 |           0.01
              1 |          16 |         28.81 |           0.62
              2 |          30 |         23.27 |           0.12
              3 |          29 |         63.45 |           0.35
              4 |           5 |          72.4 |           0.89
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |       20.97 |
    ------------------------------------------------------------

Number of Clusters: 6
    Cluster 0:
        Number of People: 21
        Average of Age: 83.43
        Average of severities: 0.07
        The Coordinates of Centroid:
            X1 (Severity): 0.07
            X2 (Age): 0.84

    Cluster 1:
        Number of People: 15
        Average of Age: 19.27
        Average of severities: 0.34
        The Coordinates of Centroid:
            X1 (Severity): 0.35
            X2 (Age): 0.19

    Cluster 2:
        Number of People: 9
        Average of Age: 29.67
        Average of severities: 0.71
        The Coordinates of Centroid:
            X1 (Severity): 0.75
            X2 (Age): 0.29

    Cluster 3:
        Number of People: 22
        Average of Age: 28.55
        Average of severities: 0.03
        The Coordinates of Centroid:
```

```
            X1 (Severity): 0.03
            X2 (Age): 0.28

    Cluster 4:
        Number of People: 5
        Average of Age: 72.4
        Average of severities: 0.89
        The Coordinates of Centroid:
            X1 (Severity): 0.94
            X2 (Age): 0.73

    Cluster 5:
        Number of People: 28
        Average of Age: 58.07
        Average of severities: 0.38
        The Coordinates of Centroid:
            X1 (Severity): 0.4
            X2 (Age): 0.58

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          21 |         83.43 |           0.07
              1 |          15 |         19.27 |           0.34
              2 |           9 |         29.67 |           0.71
              3 |          22 |         28.55 |           0.03
              4 |           5 |          72.4 |           0.89
              5 |          28 |         58.07 |           0.38
    ------------|-------------|---------------|------------------
       Total    |         100 |
        SSE     |       19.41 |
    ------------------------------------------------------------

Number of Clusters: 7
    Cluster 0:
        Number of People: 13
        Average of Age: 37.62
        Average of severities: 0.01
        The Coordinates of Centroid:
            X1 (Severity): 0.01
            X2 (Age): 0.37

    Cluster 1:
        Number of People: 14
        Average of Age: 27.43
        Average of severities: 0.65
        The Coordinates of Centroid:
            X1 (Severity): 0.68
            X2 (Age): 0.27
```

```
Cluster 2:
    Number of People: 15
    Average of Age: 75.47
    Average of severities: 0.38
    The Coordinates of Centroid:
        X1 (Severity): 0.4
        X2 (Age): 0.76

Cluster 3:
    Number of People: 5
    Average of Age: 72.4
    Average of severities: 0.89
    The Coordinates of Centroid:
        X1 (Severity): 0.94
        X2 (Age): 0.73

Cluster 4:
    Number of People: 23
    Average of Age: 43.09
    Average of severities: 0.31
    The Coordinates of Centroid:
        X1 (Severity): 0.33
        X2 (Age): 0.43

Cluster 5:
    Number of People: 17
    Average of Age: 82.65
    Average of severities: 0.02
    The Coordinates of Centroid:
        X1 (Severity): 0.02
        X2 (Age): 0.83

Cluster 6:
    Number of People: 13
    Average of Age: 12.38
    Average of severities: 0.12
    The Coordinates of Centroid:
        X1 (Severity): 0.13
        X2 (Age): 0.12

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          13 |         37.62 |           0.01
              1 |          14 |         27.43 |           0.65
              2 |          15 |         75.47 |           0.38
              3 |           5 |          72.4 |           0.89
              4 |          23 |         43.09 |           0.31
              5 |          17 |         82.65 |           0.02
              6 |          13 |         12.38 |           0.12
```

```
    ------------|-------------|---------------|------------------
       Total    |         100 |
        SSE     |       16.49 |
    ------------------------------------------------------------

Number of Clusters: 8
    Cluster 0:
        Number of People: 3
        Average of Age: 11.33
        Average of severities: 0.85
        The Coordinates of Centroid:
            X1 (Severity): 0.89
            X2 (Age): 0.11

    Cluster 1:
        Number of People: 17
        Average of Age: 82.65
        Average of severities: 0.02
        The Coordinates of Centroid:
            X1 (Severity): 0.02
            X2 (Age): 0.83

    Cluster 2:
        Number of People: 12
        Average of Age: 20.42
        Average of severities: 0.29
        The Coordinates of Centroid:
            X1 (Severity): 0.3
            X2 (Age): 0.2

    Cluster 3:
        Number of People: 5
        Average of Age: 72.4
        Average of severities: 0.89
        The Coordinates of Centroid:
            X1 (Severity): 0.94
            X2 (Age): 0.73

    Cluster 4:
        Number of People: 21
        Average of Age: 51.67
        Average of severities: 0.24
        The Coordinates of Centroid:
            X1 (Severity): 0.26
            X2 (Age): 0.52

    Cluster 5:
        Number of People: 12
        Average of Age: 34.17
```

```
        Average of severities: 0.58
        The Coordinates of Centroid:
            X1 (Severity): 0.61
            X2 (Age): 0.34

    Cluster 6:
        Number of People: 13
        Average of Age: 76.62
        Average of severities: 0.41
        The Coordinates of Centroid:
            X1 (Severity): 0.43
            X2 (Age): 0.77

    Cluster 7:
        Number of People: 17
        Average of Age: 22.76
        Average of severities: 0.02
        The Coordinates of Centroid:
            X1 (Severity): 0.02
            X2 (Age): 0.22

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |           3 |         11.33 |           0.85
              1 |          17 |         82.65 |           0.02
              2 |          12 |         20.42 |           0.29
              3 |           5 |          72.4 |           0.89
              4 |          21 |         51.67 |           0.24
              5 |          12 |         34.17 |           0.58
              6 |          13 |         76.62 |           0.41
              7 |          17 |         22.76 |           0.02
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |       15.32 |
    ------------------------------------------------------------

Number of Clusters: 9
    Cluster 0:
        Number of People: 7
        Average of Age: 70.43
        Average of severities: 0.79
        The Coordinates of Centroid:
            X1 (Severity): 0.83
            X2 (Age): 0.71

    Cluster 1:
        Number of People: 13
        Average of Age: 87.31
        Average of severities: 0.01
```

```
        The Coordinates of Centroid:
            X1 (Severity): 0.01
            X2 (Age): 0.88

    Cluster 2:
        Number of People: 17
        Average of Age: 22.76
        Average of severities: 0.02
        The Coordinates of Centroid:
            X1 (Severity): 0.02
            X2 (Age): 0.22

    Cluster 3:
        Number of People: 11
        Average of Age: 78.64
        Average of severities: 0.38
        The Coordinates of Centroid:
            X1 (Severity): 0.4
            X2 (Age): 0.79

    Cluster 4:
        Number of People: 3
        Average of Age: 11.33
        Average of severities: 0.85
        The Coordinates of Centroid:
            X1 (Severity): 0.89
            X2 (Age): 0.11

    Cluster 5:
        Number of People: 10
        Average of Age: 62.2
        Average of severities: 0.07
        The Coordinates of Centroid:
            X1 (Severity): 0.08
            X2 (Age): 0.62

    Cluster 6:
        Number of People: 14
        Average of Age: 18.21
        Average of severities: 0.34
        The Coordinates of Centroid:
            X1 (Severity): 0.36
            X2 (Age): 0.18

    Cluster 7:
        Number of People: 17
        Average of Age: 47.29
        Average of severities: 0.31
        The Coordinates of Centroid:
```

```
            X1 (Severity): 0.32
            X2 (Age): 0.47

    Cluster 8:
        Number of People: 8
        Average of Age: 41.12
        Average of severities: 0.62
        The Coordinates of Centroid:
            X1 (Severity): 0.65
            X2 (Age): 0.41

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |           7 |         70.43 |           0.79
              1 |          13 |         87.31 |           0.01
              2 |          17 |         22.76 |           0.02
              3 |          11 |         78.64 |           0.38
              4 |           3 |         11.33 |           0.85
              5 |          10 |          62.2 |           0.07
              6 |          14 |         18.21 |           0.34
              7 |          17 |         47.29 |           0.31
              8 |           8 |         41.12 |           0.62
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |        14.7 |
    ------------------------------------------------------------


Process finished with exit code 0
```

3.2.5. K-means Algorithm using Minkowski Distance Function

- **Used Columns: Age, Severity**
- **Distance Function: Minkowski Distance**

  The Minkowski distance is a metric in a normed vector space which can be considered as a generalization of both the Euclidean distance and the Manhattan distance.

  - Minkowski Distance Formula

    The Minkowski distance of order *p* (where *p* is an integer) between two points

    $$X = (x_1, x_2, \ldots, x_n) \text{ and } Y = (y_1, y_2, \ldots, y_n) \in \mathbb{R}^n$$

    is defined as:

    $$D(X,Y) = \left(\sum_{i=1}^{n} |x_i - y_i|^p \right)^{\frac{1}{p}}$$

- **Console window results**

```
"C:\Users\SELab\Anaconda3\envs\Corona Clustering\python.exe"
"C:/Users/SELab/Desktop/SELAB/04 Project Related/Corona
Clustering/pyc_clustering.py"
Total number of People: 100
ID  Age Covid Status Severity Address
1   72  Contacted    0.125    충청남도
2   50  Healthy      0.0      경기도
3   49  Contacted    0.2      경상북도
4   45  Contacted    0.225    전라남도
5   45  Contacted    0.325    전라남도
6   66  Confirmed    0.55     부산광역시
7   86  Healthy      0.0      전라남도
8   43  Healthy      0.0      서울특별시
9   63  Healthy      0.0      경기도
10  81  Confirmed    0.35     광주광역시
11  2   Contacted    0.175    경상북도
12  69  Healthy      0.0      전라북도
13  66  Healthy      0.0      전라북도
14  37  Contacted    0.425    울산광역시
15  97  Healthy      0.0      경상북도
16  98  Healthy      0.0      경상북도
17  56  Confirmed    0.65     전라북도
18  26  Contacted    0.3      경상남도
19  90  Confirmed    0.9      전라북도
20  21  Confirmed    0.5      전라북도
21  26  Healthy      0.0      경상북도
22  17  Confirmed    0.45     제주특별자치도
23  55  Healthy      0.0      부산광역시
24  74  Healthy      0.0      경상북도
25  91  Contacted    0.275    경상북도
26  33  Healthy      0.0      대전광역시
27  1   Healthy      0.0      강원도
28  91  Confirmed    0.9      전라남도
29  74  Confirmed    0.45     전라남도
30  52  Contacted    0.275    경기도
31  49  Confirmed    0.4      전라남도
32  49  Confirmed    0.3      전라남도
33  13  Contacted    0.375    경상남도
34  90  Contacted    0.175    충청북도
35  40  Healthy      0.0      경상남도
36  59  Confirmed    0.9      인천광역시
37  21  Contacted    0.3      경상남도
38  99  Confirmed    0.3      경상남도
39  20  Healthy      0.0      경기도
40  21  Confirmed    0.95     전라북도
```

41	76	Healthy	0.0	제주특별자치도
42	17	Contacted	0.125	서울특별시
43	10	Healthy	0.0	전라북도
44	50	Contacted	0.45	인천광역시
45	58	Contacted	0.175	서울특별시
46	44	Confirmed	0.6	경상남도
47	1	Confirmed	0.75	강원도
48	94	Healthy	0.0	강원도
49	96	Healthy	0.0	울산광역시
50	96	Healthy	0.0	대전광역시
51	25	Healthy	0.0	전라북도
52	68	Contacted	0.375	강원도
53	59	Confirmed	0.3	경상북도
54	50	Confirmed	0.9	전라북도
55	13	Contacted	0.225	경상북도
56	76	Contacted	0.45	광주광역시
57	48	Contacted	0.3	부산광역시
58	53	Healthy	0.0	전라북도
59	12	Confirmed	0.85	서울특별시
60	43	Contacted	0.125	경상북도
61	54	Contacted	0.275	울산광역시
62	52	Confirmed	0.45	제주특별자치도
63	31	Confirmed	0.7	제주특별자치도
64	28	Contacted	0.275	전라남도
65	40	Contacted	0.2	경상남도
66	88	Confirmed	0.5	경기도
67	27	Contacted	0.275	충청남도
68	40	Confirmed	0.45	전라북도
69	66	Contacted	0.225	서울특별시
70	49	Contacted	0.375	충청남도
71	82	Healthy	0.0	광주광역시
72	7	Healthy	0.0	전라남도
73	78	Healthy	0.0	서울특별시
74	30	Contacted	0.325	서울특별시
75	87	Contacted	0.325	전라남도
76	72	Contacted	0.375	경상북도
77	67	Confirmed	0.35	서울특별시
78	16	Healthy	0.0	경기도
79	62	Contacted	0.45	전라북도
80	24	Healthy	0.0	경상북도
81	10	Confirmed	0.55	대구광역시
82	72	Confirmed	0.85	인천광역시
83	70	Contacted	0.2	경기도
84	30	Confirmed	0.6	경기도

```
85  37  Healthy      0.0      경상북도
86  23  Contacted    0.15     전라북도
87  13  Confirmed    0.55     경상남도
88  34  Confirmed    0.25     대구광역시
89  19  Confirmed    0.25     충청북도
90  12  Healthy      0.0      전라남도
91  88  Healthy      0.0      대구광역시
92  80  Healthy      0.0      충청북도
93  13  Healthy      0.0      서울특별시
94  46  Confirmed    0.65     서울특별시
95  49  Contacted    0.325    서울특별시
96  15  Confirmed    0.25     경기도
97  37  Confirmed    0.65     경기도
98  40  Healthy      0.0      경상남도
99  65  Confirmed    0.55     충청북도
100 45  Confirmed    0.65     충청남도

Number of healthy people: 33
Number of contacted people: 33
Number of confirmed people: 34
Average Severity of contacted people: 0.28
Average Severity of confirmed people: 0.57

Number of Clusters: 2
    Cluster 0:
        Number of People: 69
        Average of Age: 50.81
        Average of severities: 0.14
        The Coordinates of Centroid:
            X1 (Severity): 0.14
            X2 (Age): 0.51

    Cluster 1:
        Number of People: 31
        Average of Age: 45.74
        Average of severities: 0.61
        The Coordinates of Centroid:
            X1 (Severity): 0.65
            X2 (Age): 0.46

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          69 |         50.81 |             0.14
              1 |          31 |         45.74 |             0.61
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |       28.95 |
```

```
    ------------------------------------------------------------

Number of Clusters: 3
    Cluster 0:
        Number of People: 41
        Average of Age: 49.2
        Average of severities: 0.54
        The Coordinates of Centroid:
            X1 (Severity): 0.57
            X2 (Age): 0.49

    Cluster 1:
        Number of People: 26
        Average of Age: 79.42
        Average of severities: 0.08
        The Coordinates of Centroid:
            X1 (Severity): 0.09
            X2 (Age): 0.8

    Cluster 2:
        Number of People: 33
        Average of Age: 25.52
        Average of severities: 0.12
        The Coordinates of Centroid:
            X1 (Severity): 0.13
            X2 (Age): 0.25

    ------------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          41 |          49.2 |             0.54
              1 |          26 |         79.42 |             0.08
              2 |          33 |         25.52 |             0.12
    ------------|-------------|---------------|------------------
       Total    |         100 |
        SSE     |       21.93 |
    ------------------------------------------------------------------

Number of Clusters: 4
    Cluster 0:
        Number of People: 35
        Average of Age: 46.69
        Average of severities: 0.48
        The Coordinates of Centroid:
            X1 (Severity): 0.51
            X2 (Age): 0.47

    Cluster 1:
        Number of People: 33
        Average of Age: 25.52
```

```
        Average of severities: 0.12
        The Coordinates of Centroid:
            X1 (Severity): 0.13
            X2 (Age): 0.25

    Cluster 2:
        Number of People: 6
        Average of Age: 63.83
        Average of severities: 0.9
        The Coordinates of Centroid:
            X1 (Severity): 0.95
            X2 (Age): 0.64

    Cluster 3:
        Number of People: 26
        Average of Age: 79.42
        Average of severities: 0.08
        The Coordinates of Centroid:
            X1 (Severity): 0.09
            X2 (Age): 0.8

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          35 |         46.69 |             0.48
              1 |          33 |         25.52 |             0.12
              2 |           6 |         63.83 |              0.9
              3 |          26 |         79.42 |             0.08
    ------------|-------------|---------------|------------------
       Total    |         100 |
        SSE     |       19.94 |
    ------------------------------------------------------------

Number of Clusters: 5
    Cluster 0:
        Number of People: 29
        Average of Age: 63.45
        Average of severities: 0.35
        The Coordinates of Centroid:
            X1 (Severity): 0.37
            X2 (Age): 0.64

    Cluster 1:
        Number of People: 29
        Average of Age: 23.62
        Average of severities: 0.11
        The Coordinates of Centroid:
            X1 (Severity): 0.12
            X2 (Age): 0.23
```

```
    Cluster 2:
        Number of People: 16
        Average of Age: 26.12
        Average of severities: 0.61
        The Coordinates of Centroid:
            X1 (Severity): 0.64
            X2 (Age): 0.26

    Cluster 3:
        Number of People: 20
        Average of Age: 78.15
        Average of severities: 0.01
        The Coordinates of Centroid:
            X1 (Severity): 0.02
            X2 (Age): 0.79

    Cluster 4:
        Number of People: 6
        Average of Age: 69.67
        Average of severities: 0.85
        The Coordinates of Centroid:
            X1 (Severity): 0.89
            X2 (Age): 0.7

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          29 |         63.45 |           0.35
              1 |          29 |         23.62 |           0.11
              2 |          16 |         26.12 |           0.61
              3 |          20 |         78.15 |           0.01
              4 |           6 |         69.67 |           0.85
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |       16.89 |
    ------------------------------------------------------------

Number of Clusters: 6
    Cluster 0:
        Number of People: 10
        Average of Age: 32.3
        Average of severities: 0.71
        The Coordinates of Centroid:
            X1 (Severity): 0.74
            X2 (Age): 0.32

    Cluster 1:
        Number of People: 22
        Average of Age: 28.55
        Average of severities: 0.03
```

```
        The Coordinates of Centroid:
            X1 (Severity): 0.03
            X2 (Age): 0.28

    Cluster 2:
        Number of People: 26
        Average of Age: 58.96
        Average of severities: 0.36
        The Coordinates of Centroid:
            X1 (Severity): 0.38
            X2 (Age): 0.59

    Cluster 3:
        Number of People: 21
        Average of Age: 83.43
        Average of severities: 0.07
        The Coordinates of Centroid:
            X1 (Severity): 0.07
            X2 (Age): 0.84

    Cluster 4:
        Number of People: 5
        Average of Age: 72.4
        Average of severities: 0.89
        The Coordinates of Centroid:
            X1 (Severity): 0.94
            X2 (Age): 0.73

    Cluster 5:
        Number of People: 16
        Average of Age: 20.38
        Average of severities: 0.34
        The Coordinates of Centroid:
            X1 (Severity): 0.36
            X2 (Age): 0.2

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          10 |          32.3 |           0.71
              1 |          22 |         28.55 |           0.03
              2 |          26 |         58.96 |           0.36
              3 |          21 |         83.43 |           0.07
              4 |           5 |          72.4 |           0.89
              5 |          16 |         20.38 |           0.34
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |       15.32 |
    ------------------------------------------------------------
```

```
Number of Clusters: 7
    Cluster 0:
        Number of People: 22
        Average of Age: 42.41
        Average of severities: 0.32
        The Coordinates of Centroid:
            X1 (Severity): 0.33
            X2 (Age): 0.42

    Cluster 1:
        Number of People: 15
        Average of Age: 85.07
        Average of severities: 0.02
        The Coordinates of Centroid:
            X1 (Severity): 0.02
            X2 (Age): 0.86

    Cluster 2:
        Number of People: 12
        Average of Age: 20.83
        Average of severities: 0.63
        The Coordinates of Centroid:
            X1 (Severity): 0.66
            X2 (Age): 0.2

    Cluster 3:
        Number of People: 16
        Average of Age: 15.19
        Average of severities: 0.07
        The Coordinates of Centroid:
            X1 (Severity): 0.08
            X2 (Age): 0.14

    Cluster 4:
        Number of People: 10
        Average of Age: 64.0
        Average of severities: 0.75
        The Coordinates of Centroid:
            X1 (Severity): 0.79
            X2 (Age): 0.64

    Cluster 5:
        Number of People: 12
        Average of Age: 48.42
        Average of severities: 0.02
        The Coordinates of Centroid:
            X1 (Severity): 0.03
            X2 (Age): 0.48
```

```
    Cluster 6:
        Number of People: 13
        Average of Age: 77.0
        Average of severities: 0.36
        The Coordinates of Centroid:
            X1 (Severity): 0.37
            X2 (Age): 0.78

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          22 |         42.41 |           0.32
              1 |          15 |         85.07 |           0.02
              2 |          12 |         20.83 |           0.63
              3 |          16 |         15.19 |           0.07
              4 |          10 |          64.0 |           0.75
              5 |          12 |         48.42 |           0.02
              6 |          13 |          77.0 |           0.36
    ------------|-------------|---------------|-----------------
       Total    |         100 |
        SSE     |       13.71 |
    ------------------------------------------------------------

Number of Clusters: 8
    Cluster 0:
        Number of People: 14
        Average of Age: 75.71
        Average of severities: 0.35
        The Coordinates of Centroid:
            X1 (Severity): 0.37
            X2 (Age): 0.76

    Cluster 1:
        Number of People: 6
        Average of Age: 14.67
        Average of severities: 0.72
        The Coordinates of Centroid:
            X1 (Severity): 0.76
            X2 (Age): 0.14

    Cluster 2:
        Number of People: 14
        Average of Age: 14.93
        Average of severities: 0.05
        The Coordinates of Centroid:
            X1 (Severity): 0.05
            X2 (Age): 0.14

    Cluster 3:
        Number of People: 13
```

```
        Average of Age: 48.46
        Average of severities: 0.04
        The Coordinates of Centroid:
            X1 (Severity): 0.04
            X2 (Age): 0.48

    Cluster 4:
        Number of People: 21
        Average of Age: 34.24
        Average of severities: 0.31
        The Coordinates of Centroid:
            X1 (Severity): 0.33
            X2 (Age): 0.34

    Cluster 5:
        Number of People: 12
        Average of Age: 48.33
        Average of severities: 0.55
        The Coordinates of Centroid:
            X1 (Severity): 0.58
            X2 (Age): 0.48

    Cluster 6:
        Number of People: 15
        Average of Age: 85.07
        Average of severities: 0.02
        The Coordinates of Centroid:
            X1 (Severity): 0.02
            X2 (Age): 0.86

    Cluster 7:
        Number of People: 5
        Average of Age: 72.4
        Average of severities: 0.89
        The Coordinates of Centroid:
            X1 (Severity): 0.94
            X2 (Age): 0.73

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          14 |         75.71 |           0.35
              1 |           6 |         14.67 |           0.72
              2 |          14 |         14.93 |           0.05
              3 |          13 |         48.46 |           0.04
              4 |          21 |         34.24 |           0.31
              5 |          12 |         48.33 |           0.55
              6 |          15 |         85.07 |           0.02
              7 |           5 |          72.4 |           0.89
    ------------|-------------|---------------|-----------------
```

```
       Total    |        100 |
        SSE     |      12.98 |
    ------------------------------------------------------------

Number of Clusters: 9
    Cluster 0:
        Number of People: 15
        Average of Age: 19.27
        Average of severities: 0.34
        The Coordinates of Centroid:
            X1 (Severity): 0.35
            X2 (Age): 0.19

    Cluster 1:
        Number of People: 17
        Average of Age: 82.65
        Average of severities: 0.02
        The Coordinates of Centroid:
            X1 (Severity): 0.02
            X2 (Age): 0.83

    Cluster 2:
        Number of People: 8
        Average of Age: 42.38
        Average of severities: 0.68
        The Coordinates of Centroid:
            X1 (Severity): 0.71
            X2 (Age): 0.42

    Cluster 3:
        Number of People: 4
        Average of Age: 78.0
        Average of severities: 0.89
        The Coordinates of Centroid:
            X1 (Severity): 0.93
            X2 (Age): 0.79

    Cluster 4:
        Number of People: 13
        Average of Age: 53.38
        Average of severities: 0.17
        The Coordinates of Centroid:
            X1 (Severity): 0.18
            X2 (Age): 0.53

    Cluster 5:
        Number of People: 17
        Average of Age: 22.76
        Average of severities: 0.02
```

```
        The Coordinates of Centroid:
            X1 (Severity): 0.02
            X2 (Age): 0.22

    Cluster 6:
        Number of People: 10
        Average of Age: 46.8
        Average of severities: 0.38
        The Coordinates of Centroid:
            X1 (Severity): 0.4
            X2 (Age): 0.47

    Cluster 7:
        Number of People: 13
        Average of Age: 76.62
        Average of severities: 0.41
        The Coordinates of Centroid:
            X1 (Severity): 0.43
            X2 (Age): 0.77

    Cluster 8:
        Number of People: 3
        Average of Age: 11.33
        Average of severities: 0.85
        The Coordinates of Centroid:
            X1 (Severity): 0.89
            X2 (Age): 0.11

    ------------------------------------------------------------
     Cluster ID | # of People |  Avg. of Ages | Avg. of Severity
              0 |          15 |         19.27 |           0.34
              1 |          17 |         82.65 |           0.02
              2 |           8 |         42.38 |           0.68
              3 |           4 |          78.0 |           0.89
              4 |          13 |         53.38 |           0.17
              5 |          17 |         22.76 |           0.02
              6 |          10 |          46.8 |           0.38
              7 |          13 |         76.62 |           0.41
              8 |           3 |         11.33 |           0.85
    ------------|-------------|---------------|------------------
       Total    |         100 |
        SSE     |       11.79 |
    ------------------------------------------------------------
```